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WORLD POPULATION AND WORLD FOOD SUPPLIES

AMONG the outstanding changes in the world since 1832, when the British Association first held a meeting at Newcastle upon Tyne, has been the great increase in population, its expectation of life and its standard of living. The numbers of human beings in the world is now estimated at 2,300 millions, and they are increasing at the rate of 20 millions a year. What are the prospects of man being able to provide the food necessary to meet such a rise in demand, what are the problems involved, and how is scientific discovery contributing to their solution? These are the subjects dealt with by Sir John Russell in his presidential address to the British Association at Newcastle this year (see p. 379).

The situation is difficult, and is rendered more so by the uneven distribution of the population of the world, the inequalities in the rate of increase, and the fact that some of the most densely crowded areas can only produce a restricted dietary.

There are three chief lines of attack, namely, extension of the food-producing area, more intensive development of the area already under cultivation and prevention of wastage and loss. At present only 7–10 per cent of the land surface of the world is practicable for cultivation, and though much of the remainder is not regarded as 'climatically suited' to crop growth, some of it may be brought into use. Progress has already been made in the improvement of marginal land. In semi-arid regions, areas previously devoted to low-production ranching have been converted into good grazing country as a result of careful classification according to ecological type, the introduction of new strains of grasses and proper systems of management. Suitable legumes, however, still remain to be found before the best results can be obtained; and in view of the importance of grassland both for the improvement of the livestock industry and the prevention of soil erosion, Sir John Russell puts forward a plea for the setting up of a Commonwealth station devoted to the study and production of herbage plants. In other districts, notably Australia, hitherto unproductive soils are being brought into cultivation following the application of trace elements such as zinc, copper and molybdenum, in which they are found deficient. Extension of the area under cultivation is particularly important in hot regions, where such commodities as oil seeds, fibres, tea, coffee and cocoa can alone be produced. Sociological problems complicate the matter in this case, for the introduction of modern efficient methods is bound to conflict with the traditional native agricultural systems. These difficulties are being gradually overcome, and in West Africa the stage has been reached where mechanization can be introduced into the native community farming. In Central and East Africa progress would be accelerated by the development of a good livestock industry, and the outlook is hopeful; for with the discovery that dams for water storage can be made with the aid of a bulldozer, and a

promising remedy for the tsetse fly trouble having been found, two of the chief barriers to cattle-raising have been removed.

Loss of good land from soil erosion is still a serious problem, and affected areas must be brought back into cultivation. Considerable progress has already been made in this direction; but though the methods of control are now understood, their application involves administrative as well as technical difficulties. Remedial measures cannot be carried out piecemeal, and large-scale planning, together with voluntary co-operation of all concerned, is essential for success. The United States soil conservation services have done excellent work in this respect, and provide a model for other countries to follow.

Increased yields can undoubtedly be obtained from the land already under cultivation, and it is along these lines that the outlook for increasing world food supplies is most hopeful. In hot climates much can be achieved by the extension of irrigation, and some schemes have already been worked out. In Asia, the first essential is an increase in rice production, and the crop offers vast scope for development. Thanks to what seemed a discovery of academic interest only, regarding the oxidation-reduction potential of water-logged soils, methods for the nitrogenous manuring of rice have now been put on a scientific basis, and yields can certainly be improved by the wider application of fertilizers. With the additional help of the plant breeder, increased production might well be looked for and a major factor in the cause of unrest among the nations of the East be removed. In the semi-arid regions of India and Africa more attention could profitably be paid to the millets.

Greater efficiency in production could also be achieved in many parts of the world by a modification in the size of holding, the introduction of improved systems of husbandry and the adoption of some form of co-operative scheme. A more generous application of fertilizers, of which fortunately there is potentially no shortage, would also greatly increase output, though at present lack of transport and industrial capacity are factors limiting their use. Mechanization has made rapid advances, and the engineer is enabling the farmer not only to grow and harvest his crops more efficiently, but also to avoid loss on storage. Grass is a most valuable product, yet losses of 30 per cent of protein equivalent may be incurred if it is turned into hay. Artificial drying, on the other hand, preserves the nutrients intact, and greater use could profitably be made of this method if more equipment were available. Increased intensification, however, favours the spread of pests and diseases, and fresh methods for their control have continually to be sought. In the case of some plants resistant varieties can be produced, while the new chlor- and phosphorus-insecticides are proving highly successful against a number of pests. Animal diseases, too, account for heavy loss, and in Great Britain alone seriously reduce the milk yield.

Industrial development is essential in the more backward countries, both to supply the necessary machinery, chemicals, etc., required by modern methods of agriculture and also to provide employment for those no longer required under the more efficient systems of husbandry. Only thus can the standard of living be raised.

New discoveries in pure science continue to be made. Some of them find immediate application in agriculture, while others may for a time appear to be of academic interest only. The discovery of the auxins, during experiments on the response of plants to light, is an example of the latter type. These growth-promoting substances are now used for a variety of practical purposes. They stimulate root cuttings, can induce the production of seedless fruits in tomatoes and cucumbers, prevent potatoes from sprouting during storage, control the pre-harvest fall of apples or act as selective weed-killers. Equally striking results are being obtained with animals. The fat content of milk can be increased by the injection of thyroxin or the oral administration of iodinated protein, while lactation can be induced in virgin heifers or barren cows by means of diethylstilbœstrol. Artificial insemination is spreading rapidly, and even greater developments in its use can be foreseen if the work in hand on transplants of ova from one cow to another can be brought to a successful conclusion.

In spite of all this progress, there are three chief limiting factors, which offer a challenge to agricultural science. The plant upon which food production ultimately depends can only utilize 5 per cent of the radiant energy available, the animal only converts 10–25 per cent of its food into human food, while only 7–10 per cent of the surface of the world is under cultivation.

In conclusion, Sir John Russell stresses the importance of the human factor. However successful we may be in solving the scientific difficulties, moral and spiritual problems lie at the root of our most serious troubles. Science offers us great possessions; but the democracies still have to learn that these possessions imply great personal responsibilities. The difficulties are great; but the outlook is not hopeless. Problems in the past, which have seemed insurmountable, have been overcome, and, given the right spirit, man might yet solve those of the future.

GREAT AMATEUR MATHEMATICIANS

The Mathematics of Great Amateurs

By Prof. Julian Lowell Coolidge. Pp. viii+212. (Oxford: Clarendon Press; London: Oxford University Press, 1949.) 21*s.* net.

WHEN in my younger days I wrote some papers on celestial mechanics, and was thus brought into the circle of the astronomers, I could not help noticing the difference in type between them and the mathematicians, to whose company I properly belonged. There were few professional astronomers, and the great majority of the fellows of the Royal Astronomical Society were amateurs; indeed, many of the most important advances in astronomy—the discovery of Uranus by Herschel, the discovery of spiral nebulæ by Lord Rosse, and the creation of

stellar spectroscopy by Huggins—had been made by men who held no astronomical appointment. Many of my new friends were men who had inherited or acquired considerable wealth, and had built observatories in the grounds of their mansions; they were most sociable and hospitable, and celebrated the meeting of the Society every month by an excellent and expensive Club dinner. The mathematicians, on the other hand, were practically all professionals; and there were no mathematical dinners, partly because the mathematicians were too poor, and partly because the mathematician, like the poet, depends on individual inspiration, and so has no urge to associate with his fellows.

With these recollections in mind, it was with interest that I opened Prof. Coolidge's new work. Where, I wondered, would he find enough mathematical amateurs to write a book about? I found at once, however, that he does not use the word 'amateur' in its usual meaning of 'non-professional'; the 'amateurs' whom he discusses are "men who were principally known for some other activity, yet whose success in the field of mathematics enabled them to make contributions of permanent value". Thus he excludes Fermat, the prince of all non-professional mathematicians (he was a lawyer), on the ground that his mathematical discoveries completely overshadowed his legal activities. Of course, neither Herschel nor Rosse nor Huggins would qualify as an amateur in the Coolidge sense.

The volume is therefore rather a curious one. It contains a great deal of information which will be new even to the reader who is tolerably well informed in the history of mathematics. Take, for example, Omar Khayyám, Pietro dei Franceschi, Antoine Arnauld, Jan de Witt and Denis Diderot; each of these is the subject of a chapter, and yet no one of them is mentioned at all in most mathematical histories. The level of Prof. Coolidge's scholarship is high, the style is lucid, and the work is enjoyable reading, though few of the researches with which it deals can be regarded as of major importance. The author tells us that the number of men included could easily be doubled or trebled; the only name that occurs to me is that of Napoleon Bonaparte, after whom a theorem in Euclidean plane geometry was named.

The first chapter is devoted to Plato. The attempt to estimate Plato's understanding of, and attitude towards, mathematics has exercised many generations of commentators, whose views have been taken into account in Prof. Coolidge's very fair and complete marshalling of the evidence. The difficulties which many find in Platonic studies are due in great measure to a difference of point of view; the modern man of science values mathematics chiefly because it is the key to the interpretation of Nature, which is his real interest; whereas Plato despised the study of this perishable world of visible things, and was willing to concede value to it only in so far as it led up to the eternal truths of mathematics. Within mathematics itself he had no sound instinct (although he lived in the great age of Greek geometry), being interested chiefly in trivial cases of harmony among numbers. "What," says Prof. Coolidge, "shall be our final judgment of Plato as a mathematician? A productive mathematical scholar he certainly was not. He had the highest opinion of the value, especially the spiritual value, of the subject. He had a bowing acquaintance with all the pure mathematics of his time. He frequently, I had almost said habitually, expressed himself obscurely if not inaccurately. I believe it to be a waste of time to look for important facts of a mathematical or historical nature under the confused statements which may indeed arise from the spiritual height of his views, but equally from a fundamental lack of grasp in his knowledge."

From Plato we pass to Omar Khayyám, whose contributions to the solution of cubic equations are little known in comparison with his poem the *Rubáiyát*; and then to Pietro dei Franceschi, the fifteenth-century painter of the Umbrian school, who developed the theory of perspective; to Leonardo da Vinci, who worked in many mathematical fields; and to Albrecht Dürer, who was the true discoverer of descriptive geometry, an honour usually assigned to Monge. A discussion of Napier of Merchiston and his contemporaries leads to the conclusion "Napier deserves the whole credit. He first saw the advantage of logarithms, put through a tremendous amount of work in calculating them by a highly ingenious method, thought out Briggs' improvement independently, and made a further improvement of his own. Our logarithm of to-day is essentially Napier's logarithm. What an accomplishment for a theologically inclined nobleman!"

Pascal is credited with (among other things) the discovery of integration by parts; and to his intimate friend Antoine Arnauld is assigned the priority in breaking away from Euclid. Jan de Witt, the Grand Pensionary of Holland (1625–72), contributed to the theory of life annuities, working out annuities based on the last survivor of two, three or more lives; while the naturalist Buffon (1707–88), who translated Newton's "Fluxions" into French, invented geometrical probability. Finally, there is an account of the Czech Bernhard Bolzano (1781–1848), Catholic theologian and philosopher, who was the first to define properly a continuous function, the first to define properly a convergent sequence, and the first to point out the property on which the theory of transfinite numbers is based, that an infinite aggregate is equivalent (in the sense of one-to-one correspondence) to a part of itself. EDMUND WHITTAKER

EARTH-LORE AND MINERAL TREASURE

Geology

An Introduction to Earth-History. By Prof. H. H. Read. (Home University Library of Modern Knowledge, No. 198.) Pp. viii+248. (London: Oxford University Press, 1949.) 5*s*. net.

Minerals and Mineral Deposits

A Conspectus. By Dr. W. R. Jones and Dr. David Williams. (Home University Library of Modern Knowledge, No. 202.) Pp. vii+248. (London: Oxford University Press, 1948.) 5*s*. net.

THESE two delightful little books deserve a special welcome, partly because they are very good value, but mainly because their authors have spared no pains to make them readable and exhilarating as well as informative and well balanced. The path of the newcomer is made smooth by the skilful presentation of modern concepts, while the professional reader is stimulated by the original and effective methods of treatment.

To undertake an adequate summary of the history, scope and results of geological investigation in fewer

than 250 pages is a far from easy task; but Prof. Read has carried his enterprise through with enviable success. The history of the earth reveals itself as a highly complex, four-dimensional, spiral-like pattern of inter-related processes and materials, and the initial difficulty in instructing the novice is to decide how best to break into the 'spiral'. Read neatly solves this problem in his first chapter by reviewing the early discoveries, with special reference to the methods of investigation devised by the pioneers. A masterly chapter follows on sedimentary rocks and the long sequence of ever-changing environments which they portray. Igneous and metamorphic rocks and the nature of the depths come next; and here, as might be expected, the problems of granitization and of the origin and mode of emplacement of granite are given a prominent place. The following chapter, concerned mainly with tectonics and orogenic cycles, leads naturally, after a breezy excursion into the choppy seas of rival hypotheses, to the fifth and last, which is a lively review of the pattern of earth history.

In his discussion of the Pre-Cambrian record of the Canadian Shield (p. 183) the author goes astray—in company with most North American geologists—by confusing Logan's original Laurentian (age about 1,050 million years) with Lawson's post-Keewatin 'Laurentian' (age about 2,000 million years). The date of the metamorphosed varved clays of Finland (p. 182) has also gone wrong: "nearly 2000" m.y. should be "about 1000" m.y. These details, however, will not trouble the general reader and they can easily be corrected in the later editions for which there will undoubtedly be a demand.

The keynote of "Minerals and Mineral Deposits" is implicit in one of its introductory sentences: "Although we live in a world mainly composed of minerals few people realise the extent to which the quest for minerals and their utilization have influenced the course of history". There follows a most fascinating chapter in which this theme is developed, from the Stone Age to modern times, in a spirit that recalls the zeal of Werner. The essentials of crystallography and mineralogy are presented with great ingenuity and sustained interest, the chapter on "Internal Structure" in particular being a delight to read for its scientific beauty and lucidity. A brief introduction to rocks leads on to the consideration of ore deposits, their origin, distribution, discovery and extraction. The chapter on "The Search for Mineral Deposits" is noteworthy for its clear and accurate summary of geophysical methods. The Wernerian keynote is sounded again in the later chapters, which deal with the modern uses of minerals and with mineral resources and their international aspects. Here, indeed, is a most valuable and up-to-date conspectus which richly justifies the publisher's claim that it contains much information not hitherto gathered together in any English book. Much of this information will certainly be a surprise and a revelation to a majority of readers.

It is curious to find that, although the three writers of the two books under consideration all come from the Imperial College and share the same geological ancestry, the respective views expressed about granite are widely at variance. Jones and Williams continue to adopt the outworn notion that granite is one of the commonest of igneous rocks, whereas Read is a doughty supporter of the more realistic idea that "most granitic rocks are formed by granitization of earlier rocks and not by consolidation from a magma". The reason for this discrepancy is probably to be found in the fact that the relation of ore concentration to granitization is only just beginning to be elucidated. Meanwhile, the traditional views concerning the origin of ore deposits, views which imply a belief in the magmatic origin of plutonic rocks, continue to hold the field by their sheer momentum. Their inconsistency with the results of current discoveries in petrogenesis should, however, have been frankly recognized, while admitting that at the moment a new approach is scarcely practicable.

But these and similar matters which still lie in the borderland of half-knowledge are subjects for future investigation. Their challenge merely intensifies the excitement of present-day geology and, with the solitary exception just referred to, it can be said of both books that they have the great merit of reflecting this current excitement. Both are friendly books which communicate to the reader something of the enjoyment that obviously attended their composition. They deserve to be widely read, and their authors have abundantly earned their readers' thanks and congratulations.

ARTHUR HOLMES

ARCHÆOLOGY OF EARLY KHARTOUM

Early Khartoum

An Account of the Excavation of an Early Occupation Site carried out by the Sudan Government Antiquities Service in 1944–5. By A. J. Arkell. (Published for the Sudan Government.) Pp. xvi+146+113 plates. (London, New York and Toronto: Oxford University Press, 1949.) £5 5s. 0d. net.

"THE excavation of this site has revealed more than it was possible to hope that it would when it was undertaken in the face of so much disturbance." This modest understatement introduces the author's summary in a publication of outstanding importance to late African prehistory. For the culture of Early Khartoum here revealed represents that increasingly rare and precious thing in prehistory—a discovery of the hitherto unknown, not, as is now usual, the amplification of the incompletely known. As such, it has no rival in the Nile Valley since Faiyum–Merimdian and Tasa–Badarian civilizations were unearthed not far short of a quarter of a century ago.

The small group of Mesolithic Khartoum Nilotes now suddenly revealed occupied the top of a sandhill on a swampy bank of the Blue Nile. In customs and equipment they were at a primitive, pre-Neolithic level of existence. Wattle-and-daub screens were their habitations; the ground below them was their casual cemetery, with flexed burials devoid of grave goods. They were a negroid community of hunters and fishermen, equipped with the gear of their calling, apparently without knowledge of domestic animals or cereals. Their tools and weapons were mainly of well-known microlithic forms; yet the typological composition, and even more the gaps in it, differentiates them collectively, more than individually, from the numerous and endlessly varied microlithic groups on record from the Nile Valley, the Libyan oases and North Africa in general, as well as from the Wilton groups to the south. The arrow-tips are of the transverse variety only, but lack the more

evolved forms of this type, usually, though not always, referable to a well-advanced period.

Other stone objects include numbers of discoidal ochre-stained grinders; these, when hollowed out by excessive wear, seem to have given rise to a series of heavy stone perforated rings, which may, the author thinks, have been club-heads. They recall similar rings in the otherwise dissimilar lithic products of the agricultural 'Para-Tumbian' Neolithic of the French Sudan and Nigerian Sahara on about the same latitude as Khartoum. Waisted or centrally grooved pebbles found in Early Khartoum also have distant connexions, for similar objects have been recorded from the Faiyum as well as from Taferjit in the Nigerian Sahara, where bone spear-heads referred to below are their surface associates. In Faiyum these stones were thought to be net-sinkers (see "The Desert Fayum", p. 66), a suggestion advanced also for the Khartoum examples.

In bone the multi-barbed spear and harpoon-heads are important for comparative purposes, though Mr. A. J. Arkell's typological sequence, based admittedly on insufficiently documented Egyptian material, may need revision. None the less, his comparisons with the barbed bone spear-heads from Taferjit and adjacent sites are arresting, though the dissimilarity of their apparently associated stone implements (recalling the Faiyum A group) raises complicated questions of interrelationship.

But, above all, it is the pottery which is most remarkable in Early Khartoum. It consists of round-based bowls of red-brown unburnished ware, scored, in its most characteristic form, by beautifully executed wavy-lines incised with fish-spines, and other subsidiary decorations also, presumably, based on basketry. Contemporary sherds of bright red pottery occasionally occur also. Clearly these wares are far from the infancy of pottery making; and they lead one to a careful scrutiny of the evidence which decided Mr. Arkell to venture the designation "Mesolithic", the chronological implications of which he fully accepts.

The evidence is both stratigraphic and climatic. The former is pieced together from other sites, where the upper dating limit is set by the long-known and misnamed 'A' group Sudanese rippled ware of Proto-dynastic date (*circa* 3000 B.C.). Separating this from the Khartoum Mesolithic is a Neolithic culture, still unpublished, referred to in this work as the "Gouge Culture". It contains a peculiar gouge-like tool, elsewhere known only in the Neolithic Faiyum, as well as some novel additions to prehistory.

The climatic evidence is unusually definite and of the greatest value to those struggling with climatic determinations in other desert areas. The Blue Nile ran at a flood-level 4 m. higher than now. The present mean annual rainfall at Khartoum is now only 164 mm.; the assemblage of mammals, molluscs and vegetation in Early Khartoum, though with one notable exception of modern species, proclaims a rainfall of at least 500 mm., comparable to that now supporting a similar wild life 200–300 miles farther south. The single exception is an extinct and archaic reed rat related to a fossil form from the Nigerian Sahara.

On the cumulative archæological and climatic evidence, Mr. Arkell justifiably concludes that Early Khartoum discloses trans-southern Saharan connexions "before the oncoming desert initiated movements of man and animals from the Saharan steppe in the direction of more favourable areas such as the Nile Valley"—a view favoured by the present reviewer, but open to a broadside from those who believe a diffusion of primitive civilization westwards from Egypt to be more probable.

The discoveries, so clearly described and suggestively presented, introduce a number of stimulating fresh possibilities into late African prehistory. The volume is sumptuously produced. The sumptuous price will prohibit its possession by the vast majority of students.

G. Caton-Thompson

ELECTRONS IN IONIC CRYSTALS

Electronic Processes in Ionic Crystals

By N. F. Mott and Dr. R. W. Gurney. (International Series of Monographs on Physics.) Second edition. Pp. xii+276. (Oxford: Clarendon Press; London: Oxford University Press, 1948.) 25*s*. net.

THE last decade has seen an increasing number of applications of modern theoretical physics to questions which are of appreciable technical importance. Often such applications arise from problems which at an earlier stage of development were of interest for the investigation of more fundamental properties of atoms and electrons. Mott and Gurney's book on electrons in ionic crystals, of which the second edition is now available, is an excellent and perhaps the first monograph on what might be called applied theoretical physics.

The first edition of this book, which appeared in 1940, is no doubt well known to all interested in the subject; a short survey of its contents should therefore be sufficient. An introductory chapter on perfect ionic crystals is followed by a chapter on lattice defects in crystals. It is shown that properties like diffusion or ionic conductivity are to be understood in terms of certain deviations from the perfect structure which in thermal equilibrium are bound to occur except at very low temperatures. The following three chapters, which deal with various electronic properties, again demonstrate the importance of defects, or of foreign additions, for many of the practically important properties. A short chapter on luminescence leads to the theory of the photographic latent image on which much progress has been made in recent years, largely due to the authors' contributions. The book ends with a chapter on properties which are believed to be due to processes involving the transport of both ions and electrons.

The second edition differs from the first one only by short additions on rectifying contacts, photographic emulsions, and the theory of oxidation. They describe briefly the results of more recent work. In dealing with such a variety of subjects—often for the first time in literature—it cannot be expected that on every occasion the proposed model, or theory, is final. It is, however, just the tentative suggestions which stimulate further research, as is shown by the frequent citation of the authors' book in original papers.

In the second edition the authors have chosen not to alter the text of the first edition, but rather to add remarks on later developments at the end of the relevant chapters, as they felt that the time for an extensive revision had not yet come. Until then, the book in its present form represents an excellent introduction to the subject. It will, no doubt, continue to be extensively used by research workers.

H. Fröhlich

Farmer's Joy

By John Read. Pp. xi+274. (London and Edinburgh: Thomas Nelson and Sons, Ltd., 1949.) 12*s*. 6*d*. net.

SO long ago as 1910 the present professor of chemistry in the University of St. Andrews founded a pioneer group of rustic players to stage his Somerset dialect plays in the villages of the West Country. These plays had grown out of the author's upbringing on the borderland of Somerset and Dorset and, in "Farmer's Joy", he has gone back to a district with which he is historically and genetically linked to produce a book which is in the best traditions of all the writers who have enriched the literature of England with their tales of the West Country told in dialect.

Most of the material on which the book is based was collected by the author at the beginning of the century. It tells of "country folk, simple but shrewd, as fond of gossip as they are of fun and cider. It mingles old customs, strange beliefs, local habits, quaint folk-songs and stories of all kinds in rich profusion". The book seeks to preserve for later generations a flavour of a Wessex which faced life leisurely and which is tending to disappear under the impact of modern conditions.

Some of the stories which Prof. Read relates are well known to West countrymen and are hallowed on convivial occasions. Others are original and have been assiduously collected from those whom they actually concerned or from their acquaintances. What may surprise the 'foreigner' is that all the stories and incidents have actually occurred and could be substantiated. Some of these stories have already appeared in various journals; but in bringing them together and in adding to them, Farmer Wookey (or Prof. Read) has done yeoman service to English dialect and West Country humour. These the stranger may better understand by referring to the admirable glossary, the remarks on the dialect and the author's notes. T. H. H.

Statistical Year-Book of the World Power Conference

No. 4: Data on Resources and Annual Statistics for 1936–1946. Edited, with Introductory and Explanatory Texts, by Frederick Brown. Pp. 212. (London: World Power Conference, 1948.) 45*s*. net.

THIS fourth year-book, produced with aid of a grant from Unesco, covers the disturbed period of the Second World War when comparisons between countries in respect of output became increasingly difficult, by reason of both the scarcity of information and widespread territorial changes. The successive tables are concerned mainly with fuels and other sources of power. Table 2, concerned with resources of solid fuels, is little changed from that of Year-Book No. 3, except in the important cases of Canada and China, the estimates for which are heavily reduced. In respect of coal output, the lengthening lead of the United States (more than 800 million tons annually) and the difficulty of the British fields in maintaining production at little more than 200 millions have been confirmed by the Second World War. In water-power, the recently increased capacity of Sweden is remarkable, even in a world of vigorous hydro-electric development. The most serious gaps in the tables are left by the absence of figures concerning U.S.S.R. output; in petroleum production, for example, there are no figures later than for the year 1936. By following the practice of placing the Soviet Union, as a whole, for statistical purposes, within Europe, the fact that its mineral wealth is preponderantly within Asia is, unfortunately, concealed. W. FITZGERALD

Visual Education Film Strips

An Introduction to Fungi, Part 1. By Rodney F. Cosser. Pp. 12+Film Strip. An Introduction to Fungi, Part 2. By Rodney F. Cosser. Pp. 12+Film Strip. Autumn Fruits (Poisonous). By Rodney F. Cosser. Pp. 12+Film Strip. Autumn Fruits (Non-Poisonous). By Rodney F. Cosser. Pp. 12+Film Strip. (London: *Daily Mail* School-Aid Department, n.d.) 21*s*. each.

ALL these strips will form a very useful addition to any school library. The subjects are admirably photographed and the colour reproduction (Dufay-chrome) is both life-like and attractive. In fact, the inexpensive film projector can be used very effectively with these strips. It may be a technical disadvantage of this particular colour process that the manufacturers are unable to include numbers to indicate frames, or titles to indicate specimens. This, however, is to a large extent counter-balanced by the notes accompanying each strip, which include monochrome reproductions of all the frames.

In "Introduction to Fungi", Parts 1 and 2, the viewer may experience some difficulty in gauging the sizes of the specimens. It might have been a good idea to introduce some common object in certain of the frames against which relative sizes could have been assessed.

The notes provided with all four film strips are good. They are perhaps too full in that they may induce some teachers to neglect further sources of information. Film strips of this kind are extremely useful for stimulating initial interest. We should like to see the *Daily Mail* produce further film strips with the main intention of saving teaching time and doing for the teacher what the average illustrated text-book cannot do.

Process and Physical Metallurgy

By Dr. James E. Garside. Pp. xix+499. (London: Charles Griffin and Co., Ltd., 1949.) 40*s*. net.

THIS is an amazing book. In just under five hundred pages of well-printed and illustrated text the author has covered a very large field of metallurgy, including fuel, refractories and moulding sands.

As the book is written primarily for engineers, detailed accounts of extraction processes have wisely been avoided. Fabrication, heat-treatment, pyrometry and the properties and uses of alloys, both ferrous and non-ferrous, have been most ably dealt with. The chapter on the technique of the metallographic microscope, which includes a brief but excellent description of the electron-microscope, is extremely well written, as are the chapters on the constitution of alloys and the metallic state.

The whole outlook of the book is thoroughly modern, and in his brief treatment of so much subject-matter the author has given just enough and not too much. It is, in fact, an extremely good example of how clarity can be gained by brevity and by reference to some excellent diagrams.

The book is to be thoroughly recommended, not only to engineers but also to metallurgists requiring a refresher course, while the layman can gain a very excellent insight into the fascinating subject of metallurgy by perusing its pages. J. H. ANDREW

WORLD POPULATION AND WORLD FOOD SUPPLIES*

By Sir JOHN RUSSELL, O.B.E., F.R.S.
President of the British Association

THERE is an old Egyptian saying that whoever has once drunk of the waters of the Nile will want to go back and drink them again. I do not know if that has ever been said of the waters of the Tyne, but it is certainly true that the British Association always welcomes an invitation to Newcastle. This is our fifth visit; to no other city have we been more often.

We came first in 1838 when England was mainly an agricultural country. The 111 years that have elapsed have seen profound changes in our national life, particularly the prodigious advancement of science and of its daughter technology.

Among the many resulting achievements has been a great increase in the certainty and the length of life. The world population has risen more rapidly than ever before; it is now estimated by the Food and Agriculture Organisation at about 2,300 millions, and the increase at about 20 millions a year—an average addition of two every three seconds day and night, year after year, and the two may become three or more as science advances, social services improve, and bodies such as the World Health Organisation become fully operative. Can they all be fed? The problem is complicated by the inequalities in the rate of increase, the less advanced groups multiplying more rapidly than the more advanced, and also by the unequal distribution of population over the earth's surface. Over most of the world the population is so sparse that it can produce its own food; some regions can produce a surplus; but a few regions are so densely crowded that they can themselves produce only a restricted dietary—England, Belgium, Egypt, India and Eastern Asia. England is the most crowded, but its highly developed export industries enable it to import food from the surplus countries, so long as they continue to have surpluses. India and Eastern Asia have fewer possibilities of imports, but their home production can be considerably intensified. Expansion of the world's food supplies depends, therefore, on extension of the food-producing area, more intensive cultivation of the area already used, and the reduction of the present heavy wastes and losses.

Extension of the Food-Producing Area

The world's total land area is 35,700 million acres, but only about 11,000 million are estimated by C. B. Fawcett to be 'climatically suited' to crop growth. Much of this, however, is at present impracticable for cultivation, and the area actually used is some 3,000–4,000 million acres: 7–10 per cent only of the land surface of the world. Some 85 or 90 per cent of this area is used for food production; the rest is for industrial crops. The food-producing area represents a world average of about 1½ acres per head which, at British yields, would give the British pre-war dietary; much less would suffice for a vegetarian dietary. The area 'climatically suited', however, is about 5 acres per head. Can any of those unused 3½ acres per head be brought into cultivation?

Agriculturists have long been engaged in widening the zone of cultivation by converting the marginal regions of their day into farm land and then pushing out into new marginal regions. The pioneers began in the coastal regions of North America, Australia and New Zealand, where conditions resembled our own, using methods that had been very successful in Great Britain. Wheat was their main crop. But in pushing inland they were brought to a standstill by the diminishing rainfall, and in Canada by the early onset of winter; everywhere their crops suffered from pests and diseases. In 1898 Sir William Crookes, in his presidential address to the British Association, startled the world by declaring that the process of expansion was nearly over, and by the 1930's the world would suffer hunger unless yields were raised. He showed how the necessary nitrogenous fertilizers could be prepared synthetically from the nitrogen of the air. Agriculturists did not accept his view. Lawes and Gilbert, old, but full of vigour and Victorian pugnacity, did what many indignant Englishmen have done before and since, wrote to *The Times* about it. But, in fact, the address was one of the most momentous the Association has ever heard; it founded the great nitrogen industry and everywhere stimulated agricultural investigators to fresh efforts.

The wheat problem was solved, but not in the way Crookes expected. Shortly after his address, the new science of plant genetics was founded, and for the first time it became possible systematically to transfer characters from one plant to another and so obtain new varieties possessing certain desirable qualities. Early ripening, shortness of straw and a high ratio of grain to leaf are all required in drought- and frost-resistant varieties, and all are heritable characters, as is resistance to rust and other diseases. World-wide search was made for varieties possessing the desired genes, pure line and other techniques were evolved, and new varieties were in time produced suitable for the marginal regions so that these became productive farm lands. By the 1930's Canada's 1898 wheat acreage of 4 million had risen to 27 million; Australia's 5 million to 16 million, and the Argentine's 7 million to 20 million; the world acreage and output rose far beyond the limits set by Crookes, and there was such a glut that wheat growers everywhere suffered greatly and relief measures became necessary; in the Argentine wheat was burnt in the locomotives instead of coal.

The dreaded catastrophe had not eventuated, but it had been averted by means wholly unexpected; one of agriculture's many illustrations of the ancient truth:

"And the things that we looked for, the gods deign not to fulfil
And the paths undiscerned of our eye, the gods unseal".

Since the 1930's, however, the wheat area of these new countries has not expanded, which has been taken to show that no more new wheat lands are available. The deduction is unjustified. Agricultural development of new lands is very costly, requiring

* From the Presidential Address delivered at Newcastle upon Tyne on August 31.

development of transport, storage and marketing facilities, and it is not undertaken unless a profitable market for the produce is assured. The glut of the 1930's had a restraining effect on development. Even the War has not stimulated much expansion. In 1940 Canada raised her acreage to 28·7 million in response to our urgent appeal; but the difficulties of disposal caused such discouragement that in 1941 the area fell to 21·9 million acres, and even now is only about 24 million acres, this being all that present conditions justify. All the same, Canada was able last year to supply three-quarters of British imports of wheat and flour. We owe a great debt to Canadian cerealists who made this possible—L. H. Newman, C. H. Goulden and their associates—and to the agricultural engineers who excelled themselves in devising implements for cultivating the soil, sowing and harvesting the crop with the minimum of man-power.

A new and very promising attack on the marginal lands is now being made. It is the soil-climate complex, not the climate alone, that determines agricultural use. The climate factor may be beyond our control, but the soils are being improved. Marginal lands are generally used for ranching—often many acres to one animal. Their present use is for low-productive ranching only. The more tractable are being converted into properly managed grazing land. The approach is ecological; the vegetation is surveyed, the types classified, and methods of management and conservation are worked out for each type. In South Africa more than a hundred different types of veld are recognized, each requiring its own system of management. Seeding with better grasses is being widely practised, particularly in the United States; the world is ransacked for suitable types. Canada and the United States took crested wheat grass from Russia; Australia has taken grasses from the Mediterranean countries, Africa, Turkestan and India; they are grown at the experimental stations, and suitable strains are selected and multiplied. Cross-breeding has begun. Good work is in progress at Saskatoon, Swift Current and Kamloops in Western Canada, and by Australia's vigorous Division of Plant Industry and, of course, in the United States. Unfortunately some of the good drought-resisting grasses do not easily form seed under cultivation, though they do so readily in their wild habitat. The cross-breeding of the semi-arid types has scarcely started, though collections such as that of I. B. Pole Evans in South Africa, D. C. Edwards in Kenya and others afford good material. In view of the very great importance of grass for soil conservation in all parts of the British Commonwealth, it is highly desirable that a well-equipped Commonwealth station should be established to study existing semi-arid types and produce new ones. One of the great needs now is for leguminous plants that will do for the semi-arid and tropical regions what subterranean clover and lucerne have done for the moister regions.

Large tracts of land hitherto unfertile are gradually yielding up the secret of their barrenness. Australia has made great progress. In large parts in the south the cause was the lack of trace elements: zinc, copper, molybdenum and others; these being supplied, the soil under proper management became productive. In the attractive Albany region are 300,000 acres to be made into 400-acre farms. For the large parts in the north, however, the secret is not yet discovered, nor has it been for the 300 million acres of peat and muck soils in Canada. But in both countries scientific workers are studying these problems under the organisation in Australia of Sir David Rivett, and in Canada of Dr. E. S. Archibald, E. S. Hopkins and others. Soil barrenness in New Zealand is ably investigated by Sir Theodore Rigg and his colleagues at the Cawthron Institute.

The wheat belt which once stopped at about the line of 18 in. of annual rainfall now stretches to the 12–15 in. line (dependent on the evaporation), and the utilizable grass belt down to the 8–10 in. line. There are, of course, difficulties in developing regions of erratic rainfall, particularly the old Joseph problem of storing the surpluses of good years for use in bad years; but these should not be insuperable.

The hot regions of the world present special problems because they can never be closely settled by white people. Australia's empty north has vast areas of natural grassland with adequate rainfall for beef production, and bulldozers have revolutionized the making of dams for water storage. The development problems are discussed in an excellent report by W. L. Payne and J. W. Fletcher (1937). They include land and tenure reform, pasture improvement, better living conditions for the resident workers, better abattoir facilities and transport. A chilling process based on the low-temperature research at Cambridge can now replace the old unsatisfactory freezing technique whenever the quality of the beef justifies the cost. The possibilities of arable cultivation have been greatly increased by the development of the disk plough and other implements; the Overseas Food Corporation is proposing to develop 315,000 acres of Northern Queensland, mostly for arable crops, including sorghum varieties suited for mechanized culture.

Africa's problems are fundamentally different. The small native peasant is already in occupation with his own traditional ways of life. Yet he alone can supply some of the products vitally important to us—oil seeds, fibres, tea, coffee and cocoa. The problem is to replace his primitive methods by modern efficient methods without too great disturbance of the best elements in the native life. We may be justly proud of the splendid pioneering work of the British agricultural officers; Great Britain has done more than any other country for the opening up of Africa. The Sudan Plantation Syndicate has for many years been highly successful in combining modern scientific cultivation methods with a way of life acceptable to the native and justifiable before the bar of civilization. In West Africa progress has gone so far that mechanization can now be introduced into the native community farming: this has been discussed in the excellent Clay–Monson report. As in Australia, the bulldozer's remarkable power of scooping out 'water holes' promises greatly to facilitate development. In Central and East Africa scientific workers at Amani and in the Departments have paved the way for the huge scheme of developing 3¼ million acres of savannah land, hitherto empty because of the tsetse fly and lack of surface water—troubles now capable of reduction. The unfortunate decision to rush this scheme through has been responsible for much costly disappointment for which, however, the scientific and technical staffs are in no way to blame. Progress would become still more rapid if a good livestock industry could be developed; this would necessitate not only better animal health but also more and better food supplies for the animals. The native problems have been lucidly discussed by Sir Alan Pym in his book "Colonial

Agricultural Production" (1946). The fundamental scientific problems are investigated in Britain under Sir John Simonsen and the Colonial Office Research Council, and in East Africa by a research team under B. A. Keen. Development organised by the Colonial Office is proceeding more rapidly and systematically than ever before.

Difficult human problems are bound to arise, however. The high costs necessitate high output, and the conservation of the soil requires strict control of land use over wide areas. Close supervision by advanced white people will be essential until Africa has its own highly efficient universities, research workers and chemical and engineering industries. African students have been brought to Britain for higher training, but for some their stay has been made unprofitable by inadequate social arrangements, or even by hostile political propaganda.

The wet tropics (50 in. or more rainfall per annum) contain more unused land than any other vegetation region in the world. Sir Harold Tempany has discussed the possibilities of the British portion; the Belgians have done much useful work in the Congo; and the United Nations Educational, Scientific and Cultural Organisation proposes a survey of the vast forest basin of the Amazon. Dr. C. E. Kellog and other American experts are hopeful about the utilization of part of these regions.

At the other end of the temperature-scale lie the cold, leached soils of the northern latitudes, the podsols, naturally under coniferous forest but brought into cultivation as need arises. The Finns—the most northerly farmers of the world—the Canadians and the Russians are all studying the problems involved, while the Swedes, at their incomparable station at Svalof, have produced varieties of arable crops well suited to the conditions.

But we need not go abroad for marginal and waste land; we have plenty at home here in Britain; this also can be reclaimed by conversion first into grassland, then if need be into arable. Sir George Stapledon and his colleagues at Aberystwyth have produced suitable strains of grass and clover; their use is investigated by William Davies at Drayton. R. Ellison has reclaimed much waste hill-land in Montgomeryshire and estimates that 1,000 acres so reclaimed could provide for an additional 250 store cattle. Some half-million new acres were brought into cultivation in the nine years ending June 1947.

Even light sands, long abandoned as waste or left to the foresters, are now being put down to suitable grasses or lucerne and used for dairying. Norfolk and Suffolk have some excellent examples of reclamations brought about by enterprising farmers and landowners. *Spartina Townsendii*, shown in 1923 by F. W. Oliver to Lotsy and Verhoeven as a reclaimer of mud flats, has proved very successful in Holland and may yet provide much new land there and in Britain also.

In short, wherever cultivation is now practised, there are possibilities of extension, and no one can say how great they may be.

Soil Erosion

Against these potential gains, however, must be set the very serious losses due to soil erosion. This was really an old trouble to the Mediterranean and Eastern peoples; but it was new to the agricultural pioneers who went out from Great Britain and Western Europe, and they did not realize how greatly the regions to which they were going were liable to it. Unwittingly their practices favoured it: uncontrolled felling of trees in the moister regions led to water erosion, while in the drier regions exclusive grain cropping with finely cultivated fallows to destroy weeds and conserve soil moisture—a false expectation based on the faulty soil physics of the time—broke down the soil crumbs into fine dust which was blown away by the scorching winds of the hot, dry summers.

In Africa great losses have long resulted from uncontrolled burning and over-grazing the grasslands, exposing the bare soil to the beating of the torrential rains characteristic of semi-arid regions, washing it away and often leaving great gullies; and matters were made worse by the success of the health and other departments in increasing the human and animal populations. It was the dust storms of the dry 1930's in the United States, and in particular a terrifying one on May 16, 1934, that made all America aware of the 'Dust Bowl' and the need for drastic action. In the United States some 330 million acres out of 460 million acres of good arable land were estimated to have suffered, as had something like half of the wheat land of Australia, great areas in Africa, Asia and elsewhere. A useful account is given in G. V. Jacks and R. V. Whyte's "Rape of the Earth"; but there has been much sensational writing which may, however, have stimulated action.

The United States was the first to act, and set up very successful soil-conservation services and a superb model: the Tennessee Valley Authority.

It is now recognized that erosion comes about through wrong use of the land, and the remedy is correct utilization, both of land and of water, applied over the whole catchment area. The problems are therefore not exclusively technical but administrative also. A vegetation plan must be drawn up to ensure continuous cover of critical areas—hilltops, slopes, etc.—with trees or grass, and the protection of arable land against soil movements and run-off of water by mechanical devices such as contouring, alternate strip cultivation, etc. For full effectiveness the plan requires the collaboration of the ecologist, the agriculturist, the forester and the plant breeder; the ecologist to ascertain what plant combinations are most appropriate, the agriculturist and forester to select those of most economic value, and the plant breeder to narrow the gap between the ideal plants and those actually available. Grass plays a vitally important part; it not only covers and protects the soil, but also builds up the fine particles into crumbs by processes not yet understood; successful treatment largely depends on the selection of the right grasses, particularly rhizomatous or stoloniferous types. A large amount of successful conservation has been done and much eroded land has been rehabilitated. The United States Conservation Service under H. H. Bennett now operates over some 1,100 million acres—three-quarters of all the farm and ranch lands. The 'Dust Bowl' States—Oklahoma, Kansas and Texas—are now producing much more wheat than they did before the 'Bowl' was heard of. The very sound Canadian prairie rehabilitation programme is in vigorous operation; in all the Australian States affected—especially New South Wales and South Australia—there are active soil conservation departments, and W. Hartley, of the Division of Plant Industry, is studying suitable grasses. Much good work has been done by I. B. Pole Evans in

South Africa, W. S. Martin in East Africa, R. R. Staples in Southern Rhodesia, and by others in the Belgian Congo and elsewhere.

Soil erosion could be dealt with much more easily if the problems were solely technical; unfortunately, the need for recasting the vegetation of a whole catchment area often cuts across all sorts of social or tribal customs, personal or sectional interests, political boundaries, etc., and raises many complex administrative problems. A few recalcitrant objectors could spoil the whole plan; it must be enforceable by law, but voluntary co-operation of all concerned should be the aim. The United States soil conservation laws achieve this admirably and have furnished models to other countries. The farmers and landowners of the region are invited to meet the Government and State experts, and a plan for proper land utilization is drawn up; any necessary material help is given. The farmers, feeling that the plan is at least in part their own, support it; there is not the automatic opposition given to a plan imposed from above. South Africa also has a comprehensive conservation law. The over-populated and over-grazed areas of Africa present special difficulties where the remedial measures conflict with treaty rights and tribal customs; agitators have not scrupled to stir up trouble, and much interference with useful work has been reported in the native areas of Kenya. Fortunately, the white governments concerned—the British, South African, Rhodesian, French, Belgian and Portuguese—recognizing the truth of General Smuts's dictum that soil erosion in Africa transcends all political problems, have agreed to co-operate and to set up an information office in Paris and a soil research organisation in Africa. The many problems met with in the British Colonial Empire have recently been ably discussed by Sir Harold Tempany.

An elaborate plan has been drawn up for dealing with erosion in the U.S.S.R. In most other affected countries, except perhaps China and parts of South America, the need for control is recognized and the lines of action laid down.

Rehabilitation is necessarily slow, and there are no good figures to show how far it has gone. The estimates currently quoted are those of the early 1930's, when the need was just being recognized and the bias was towards all-inclusion. It is therefore impossible to say whether rehabilitation has yet caught up with erosion. But those engaged in the work are hopeful about the outcome; the control measures are known to be effective. Moreover, erosion is associated much more with extensive and mono-culture systems of agriculture than with the intensive mixed farming systems that will necessarily be more widely adopted as the demand for food increases.

Intensification of Cropping

The most hopeful way of increasing world food supplies is by more intensive cultivation of the land already in use. It is especially important for Asiatic and African peoples—sixty per cent of the population of the world—for they have no prospect of emigration and very little of food imports from other continents. Their present product is chiefly grain, the yields low and uncertain, the methods inefficient. Experimental farms in India commonly obtain twice the yield of the neighbouring peasants, and there is often no physical reason for the disparity. But the difficulties of levelling-up are enormous; they spring from the peasants' poverty, their overflowing fecundity and the consequent minute sub-division of the land; these can only slowly be remedied.

Meanwhile, some improvement is possible. Irrigation can still be considerably extended. The projected Nile schemes, if realized, will solve Egypt's problems for a generation, while Asia, which already has some seventy per cent of the irrigated area of the world, mostly in the Himalayan region, can greatly increase the area served by tube wells as developed by Sir William Stampe.

Asia also offers vast scope for fertilizer use. Rice is the crop most affected; it is perhaps the most crucial crop in the world, for it is the main food of Asia, and its shortage is one cause of unrest there. It has been much studied in India, and improved varieties have been raised by pure-line selection; hybridization is scarcely begun. Nothing would more greatly increase its output than wider application of nitrogenous fertilizers. But rice is mainly a swamp crop, and ordinary methods of fertilizer use break down. Nitrate of soda is relatively ineffective; sulphate of ammonia often acts well but sometimes not. These puzzling complexities were resolved from a quite unexpected quarter. Prof. W. H. Pearsall, in studying marsh conditions in Cumberland, found measurable differences in oxidation-reduction potential in the water-logged soils; oxidation took place at the soil-water surface, but reduction lower down. Directly they heard of this, the Japanese experts saw its bearing on the rice problem. Sulphate of ammonia put on the surface of the mud in the usual fashion, at or before transplanting, was quickly oxidized to nitrate, which washed down below and was reduced to gaseous nitrogen. But if the sulphate of ammonia was pushed down through the oxidation zone into the region of reduction, it lay safely until the plant roots took it up. If nitrates, for example, ammonium or sodium nitrate, are added during the period of rapid growth, they can be absorbed quickly before they reach the reducing layer; therefore they may be used as later top dressings. The study of these oxidation and reduction zones showed also how cyanamide and other fertilizers should be applied. It gives for the first time a scientific basis to the manuring of the rice crop; another example of the far-reaching results that may come from a purely academic inquiry well carried out.

The human problems are more difficult. Will Burma under her new management retain her leading position* among rice exporters? And can Siam and Indo-China produce as efficiently as before? How will India fare if they do not?

The millets are specially important as native food in the semi-arid regions of India and Africa. We have done less work on these than we should; but this is to be rectified in the East African research scheme.

The general methods of intensification of food production are the same everywhere. Land tenure and size of holding usually need modifying to encourage higher efficiency; the holding should be of such size that one man can adequately supervise it. More productive systems must be evolved, and bare fallows replaced by tilled crops and by grasses and leguminous plants. Inevitably there comes a development of livestock. In the highest and most productive systems livestock products yield far more income than cash

* Before the War Burma exported almost 3,000,000 tons of rice annually out of a total export of more than 7,000,000 tons from South and East Asia.

crops; before the War livestock accounted for 70 per cent of the value of British farm produce, and according to Leitch and Godden's estimate, consumed on the average about 100 million million calories per annum—just about double the consumption of all our human population, and giving us in return less than ten million million calories. But it is only fair to say that they supply other essential needs; that most of the foodstuffs they consume are useless to humans, coming from grass, straw and various industrial and other residues; and that they greatly enhance the productiveness of the soils.

Intensification is greatly facilitated by the adoption of some form of farmers' association allowing joint and economical use of complex appliances, buying and selling operations, etc. In Denmark co-operation, and in Great Britain a variety of contract and co-operative methods, have been used with great success; in the U.S.S.R. collectivization is adopted. Whatever the method, it must suit the psychology of the farmers and be freely adopted by them if it is to have much chance of success.

Chief among the intensification methods is the improvement of the soil by fertilizers, lime, drainage, etc. Fertilizer requirements are ascertained by chemical analysis and by statistically controlled field trials as used by E. M. Crowther and F. Yates at Rothamsted or by foliar diagnosis and plant analysis, as used by T. Wallace and his colleagues at Long Ashton, and for sugar cane by Pierre Halais in Mauritius. Trace elements are studied by spectroscopic methods developed at the Macaulay Institute, Aberdeen, the Waite Institute and the Division of Soils, Adelaide, and elsewhere, while W. A. Roach at East Malling has ingeniously tackled the problem of supplying them.

Happily the necessary fertilizers are producible in almost unlimited amounts; the nitrogen comes from the air, to which in due course it returns; the known deposits of phosphate are estimated to suffice for some thousands of years at present rates of consumption; those of potash are also abundant. So far, only Western Europe and Great Britain use much fertilizer, between them taking nearly half the world pre-war production*. The War has brought about a great increase in consumption; both in Great Britain and in the United States this has doubled since 1938. World consumption of nitrogen before the War was 2 million tons annually; the present declared need is for about 4 million tons, and the factory capacity is of the same order†. In moist regions nitrogenous fertilizers have more than fulfilled Crookes's expectations; they saved the people of Britain from hunger in the two World Wars, and with clover and lucerne are our best source of the protein equivalent necessary to produce the milk and meat we so greatly need. In drier conditions phosphates are more effective; they have greatly improved the Australian and New Zealand pastures, thus providing large quantities of much-needed lamb and butter. Much more fertilizer could advantageously be used if factory capacity and transport were available. A better fertilizer supply and more leguminous cropping would quickly raise output over large parts of the world.

* The consumption per acre was in the following order: Holland (highest), Belgium, Germany, Denmark and Great Britain, France, and the aggregate was 846,000 tons of nitrogen and nearly 1,500,000 tons of phosphate out of a world consumption of just over 2,000,000 tons of nitrogen and 4,000,000 tons of phosphate.

† Excluding the U.S.S.R., Northern Korea and the Russian zone of Germany, for which no figures can be obtained. The consumption figures (F.A.O.) include technical requirements which, before the War, amounted to about 10 per cent of the total.

Along with more fertilizer goes the need for better seeds and better varieties; here the British farmer is particularly fortunate.

But all improvements fail unless weeds—arch enemies of mankind—are adequately controlled. Their destruction is one of the chief tasks of arable farming; chemical methods are coming in, but cultivation is the standard method; this and the preparation of a seed bed are usually its main purposes. Research on implements is done at the Farm Machinery Institute at Silsoe under W. H. Cashmore, and on field effects by E. W. Russell at Oxford.

Among the most significant changes in modern farming have been the increasing mechanization and the alacrity with which the younger farmers have accepted it. Tractors are displacing working horses—perhaps too rapidly.

Before the War about 60,000 tractors and 650,000 horses were used for agriculture in Great Britain. In 1948 there were more than 260,000 tractors, mostly ranging from 12 to 40 h.p.*, a gain of more than 200,000; in the same period horses were reduced by 192,000. Assuming with the Oxford Agricultural Economics Research Institute that the effective working power of one tractor is, on the average, the equivalent of four horses, British farms had in 1948 1½ million 'horse equivalents' compared with the pre-war 889,000, a gain of 68 per cent. During the War the quantum of output per man-year rose about 10–15 per cent; but the evidence available for the past five years suggests that, despite additional power and machinery, annual output has been below the war-time peak, while the total labour force on farms, allowing for changes in composition, has remained well up to war-time strength. Clearly there is room for more economical use of farm power.

It is impossible to forecast what the tractors of the future will be like; the United States already has some of 140 h.p. The limit is likely to be set by the amount of oil fuel available; the French foresee a shortage and are starting experiments on the production of methane by fermentation of straw. Tractors require their own special implements, which must be generalized and mass-produced to keep down their cost; they can no longer be made by local craftsmen to suit local requirements, like the old types; their manufacture is shifting to the industrial regions of the Midlands and Yorkshire—Canadian and American firms are recognizing the possibilities.

These engineering developments are enabling farmers to cope with the ancient difficulty that Nature's production of food is by jerks, while consumption is fairly steady. Storage is therefore necessary; usually it has to be done on the farm, and it is often attended by considerable loss. Grain crops may suffer from rats and mice, and these are estimated to destroy 2 million tons of food annually in England and Wales alone; a single rat is said to consume 50 lb. of grain a year and to spoil an additional 1½ cwt. Grass, a most important and for long most neglected crop, when made into hay commonly loses 30 per cent or more of its valuable protein equivalent, according to S. J. Watson's estimate; but, in any event, haying is inapplicable for modern intensively managed leys or lucerne that give three heavy cuts of highly nutritious material a year. Artificial drying preserves the nutrients intact; it requires 10–15 cwt. of coke per ton of product; 3 tons of dried grass per acre can be obtained—three

* The tractor statistics include market garden types of lower h.p.

time the old average yield of hay. Ensilage is cheaper, but involves loss of 20–30 per cent of the nutrients; lack of driers makes it at present the more practicable alternative.

Increased intensification necessitates strict measures against pests and diseases which now travel widely and are favoured by the greater crowding of crops. Resistance is fairly frequently a heritable character, and once the genes are found, resistant varieties can be produced, such as the rust-resistant wheats of North America and Australia, and the potatoes bred at Cambridge and at Corstorphine. The pathogen may exist in several strains, necessitating the introduction of several genes. The work is never-ending, for a relatively harmless organism may suddenly change, like the *Verticillium* which, having long lived an almost blameless life in the Kentish hop gardens, about twenty years ago suddenly produced a virulent mutation which has since done much damage there.

Measures for protecting plant and animal health are being steadily improved; they are the subject of important international conferences; if in spite of all precautions the attack still comes, countermeasures can often be taken. Plant virus diseases still defeat us, but the able and persistent efforts of F. C. Bawden, N. W. Pirie, Kenneth Smith and others cannot fail to bear fruit. Against insects the new chlor- and phosphorus-insecticides are very potent, and methods of spraying have greatly improved; even wireworms, long invincible, have succumbed to hexachlorbenzene. But there are always risks in interfering with Nature; the D.D.T. which was so effective against codling moth in orchards also killed the insect that had kept in check the red spider, and this not being affected by the D.D.T. became in its turn a pest.

Animal diseases—to which we in Britain are very liable because of our large imports of animal carcases—are steadily being brought under control. The old method was instant slaughter to avoid spread; it was effective but costly. The modern method is to apply diagnostic tests so as to catch the disease early, then to segregate and give the appropriate treatment. Vaccines are used for a number of diseases, and immunization by the appropriate serum is growingly practised. Estimates of loss are always rather speculative, but before the War the loss of milk due to disease in England and Wales was estimated at 200 million gallons per annum. More definite is the fact that the present life of a cow in the milking herd averages about 3½ lactations only; it should be 6 or 7.

Most countries could increase their food production considerably by applying known methods of improvement and raising the average performance to the level of the best. The yield of wheat in Great Britain used to be about 8 or 10 cwt. per acre; it now averages 20, and the best farmers get 30 or 40; but the world average is only about 7. A pedigree breeder may export a bull for £3,000; a scrub bull may be dear at £30. The average milk yield of England and Wales is about 550 gallons; recorded herds average about 700, and yields of 1,000–1,200 gallons a cow for a whole herd are not uncommon. Trained advisers, recently considerably augmented in number, have long been trying to reduce these gaps.

The old agriculture could be carried on by appliances made by local craftsmen. Modern intensified agriculture cannot; it demands high-grade machines, chemicals, sources of energy that only a highly developed industry can supply and, of course, corresponding standards of education among the farmers. A food producer on the old system can feed about 4 to 5 persons—this is still a very common number; on modern systems he can feed about 15 or 20, provided some of these supply him with the necessary appliances. In the self-sufficient countries of Western and Central Europe, about 20–30 per cent of the population is agricultural; in Eastern Europe and in Asia the proportion is 60–70 per cent or more, and the standards of living are much lower. They can still be raised, but marked improvement can be obtained only by taking some of these redundant people off the land and setting them to make the appliances for a better agriculture, and providing the necessary transport and buildings.

But this raises new problems; it involves segregation, as seen very clearly in England where the difference in outlook between town and country is sharply marked, and knowledge of the countryside is often curiously lacking. So we hear exhortations to more food production, but at the same time the land on which alone this can be done and the money necessary to do it are steadily taken away for other purposes. Some land reclamation, it is true, has been done; in the nine years 1939–47 the area of rough grazings in England and Wales fell by 1·4 million acres, much being brought into cultivation. But a larger area, often of better land, went out of cultivation, and the total land under crops and grass shrank by 316,000 acres, according to the official statistics*. It is hard to find a countryman with a good word to say for planning. In the end, common sense has a way of prevailing, and we may still look for further intensification of production even in our highly cultivated lands, still more in the less developed regions elsewhere. From the present small and shrinking allocation of land in Britain we may yet raise half our food, besides improving the quality of both meat and milk. And the less developed countries can feed their people better than they now do.

New Uses of Science in Food Production

Pure science is continuously opening up new possibilities for use in agriculture. The starting point is commonly some purely academic problem of no apparent practical interest whatsoever. R. A. Fisher's investigations on the theoretical foundations of statistics, ably developed by F. Yates, have revolutionized agricultural experimentation by enabling investigators to make valid estimates of the significance of their results. Frequently the physiologist has started the chain of inquiries, followed by the biochemist and the organic chemist, and finally the technological chemist.

One of the most fruitful series of investigations began with the old inquiry: Why do plants turn their leaves towards the light? Went and Kögel at Utrecht showed that the response was due to minute amounts of an organic compound which operated by causing growth of the tissue where it happened to be. Several of these growth-promoters were found; they are called auxins and have a fairly simple chemical pattern—a straight-chain acid group combined with a benzene, naphthalene or indolyl group; indole-3-acetic acid is one of the commonest.

* Prof. L. Dudley Stamp puts the net loss at 438,954 acres, after allowing for some 500,000 acres of reclamation. The difference largely turns on the definition of 'cultivation'. In the official figures for 1948 the ten-year fall is given as 270,000 acres.

These and similar substances were soon prepared on a large scale and were shown to promote root formation in cuttings: Zimmerman and Hitchcock at the Boyce Thompson Institute investigated the action in detail, and horticulturists used it in practice; these and other effects are being followed up at East Malling under F. G. Gregory. Later it was found that these auxins induced the setting of fruits of the tomato and cucumber family without the intervention of pollen from the male organ; workers at Wisley, Long Ashton and Wye have all been active here. A spray of β-naphthoxyacetic acid, 40 parts per million of water, has been used considerably by commercial growers; the fruits are normal in appearance but not yet in quality, and they are seedless. Some fifty substances of this type have been tried by R. L. Wain and Daphne Osborne at Wye, and L. C. Luckwill at Long Ashton; each has some effect on the habit of growth of the plant or the character of the fruit—not always desirable—but a considerable range of control is possible.

So far no substances have been found effective for large fruit trees except some varieties of pear.

Another important action of the auxins was discovered by W. G. Templeman, E. H. Slade and W. A. Sexton at Jealott's Hill, and somewhat later, but quite independently, by P. S. Nutman and J. H. Quastel in following up some of H. G. Thornton's work at Rothamsted. It was naturally expected that auxins might increase seedling growth; but they did not—they even killed some but not others. Cereals were much less injured than some of their common weeds, and selective weed-killing became a possibility. Chlorine atoms were introduced to give sufficient stability and greater toxicity. 2 : 4 dichlorophenoxyacetic acid (called for short 2 : 4 D) is very effective and now widely used, especially in North America; some 5–10 million acres of grain were expected to be treated in Canada last year. G. E. Blackman at Oxford with a team of workers is developing this chemical control, and important practical results may be confidently expected.

Others of these compounds are used for checking growth: preventing potatoes from sprouting in storage; staggering pineapple harvests in Hawaii to fit the canning facilities; preventing the pre-harvest fall of apples, etc. Other substances change vegetative shoots into flowering shoots. No one can see the end; and, I repeat, it all started with the purely academic inquiry: Why do plants turn their leaves to the light?

Another investigation that may have far-reaching effects is being done jointly by a team of workers under R. Brown of Leeds and A. R. Todd at Cambridge. Brown and M. Edwards had shown that the seeds of *Striga*, a plant parasitic on sorghums and millets and the cause of much loss in Africa and India, germinate only when stimulated by a substance excreted from their roots. Todd found it to be apparently a sugar: D-xyloketose acted well. If the different varieties of sorghum should differ in their ability to prepare and excrete this stimulant, a chemical test might be devised that would greatly assist plant breeders searching for resistant strains.

It is possible that other parasitic fungi can live only on varieties of plants capable of producing the necessary stimulant.

The cysts of the destructive potato eelworm hatch out only when stimulated by a substance excreted by the roots of potatoes, tomatoes and other Solanaceæ; this also is being studied by A. R. Todd. When this is identified and prepared on a large scale, it might be applied to the land while fallow, so that the emerging larvæ could perish of inanition before the potatoes were planted.

Various soil organisms are known to produce antibiotic substances, analogous to penicillin, highly destructive to certain other organisms. Thaysen and others have found in tropical soils bacteria with high powers of inhibiting the growth of fungi. In the absence of a good soil fungicide, it is possible that soil-borne fungal diseases such as 'take-all' disease of wheat and Panama disease of bananas might be successfully controlled by introducing or encouraging organisms producing the appropriate antibiotic. Bacteriophages, destructive to various bacteria, are also known to exist in soils, though they have as yet found no application in agriculture. Add to this list the large number of Protozoa, Acrasieæ and giant Rhizopods found in soil by B. N. Singh and other Rothamsted workers, and shown to feed on bacteria and other soil organisms, and it is clear that life within the soil is as full of risks as life on the surface. Some degree of control of this vast soil population so vitally important to soil fertility has long been sought, and the older method of partial sterilization may in due course be supplemented by newer agencies.

Some of the algæ and fungi, especially the yeasts, have remarkable power of synthesizing fats and proteins. Only limited use has so far been made of this property, but the possibilities are considerable. H. A. Spoehr and his colleagues at the Plant Biological Institute at Stanford, California, showed that the composition of the dry matter of *Chlorella* could be varied widely by suitably modifying the environment; the fat could be raised to 50 per cent or the protein to 75 per cent.

Moreover, there still remain unknown possibilities in the oceans, for they carry much more vegetation than the land. Prof. Lily Newton is dealing with this matter in her presidential address to the Botany Section.

Genetical science can still do much more to help crop production. To give only one instance: wide crosses often produce sterile offspring. But treatment with colchicine in some cases doubles the chromosome number and makes the offspring fertile. New types can thus be synthesized which can be used for producing new economic forms.

Ecology is also coming in to help. The old idea that science would enable the farmer to go anywhere and produce anything has given place to the more realistic principle that every acre of land should, as far as possible, be used in the way to which it is best adapted. Extensions of the cultivated area, treatment of eroded land and improvement of wild pasture are already seen as ecological problems, but the range is much wider and the possibilities great.

Many of the vital processes in animals are, like those of plants, determined by chemical substances, and some degree of control has already been attained. H. D. Kay at the National Institute for Research in Dairying, Shinfield, has shown that thyroxin injected subcutaneously, or iodinated protein (casein) fed by mouth, increased the fat content of the milk and also raised the yield up to 20 per cent after the peak of lactation was passed. Even more dramatic was the use of a synthetic œstrogen, diethylstilbœstrol, introduced in tablets under the skin, for inducing lactation in virgin heifers or barren cows—the first stage in making the male redundant.

Artificial insemination is already widely used, and is rapidly spreading, especially for dairy cattle, as milking capacity is largely inherited from the sire. Much successful upgrading has been done in Denmark; some half-million cows were inseminated in 1946, but this is only a beginning. J. Edwards estimates that by suitable dilutions the number of cows inseminated per bull could rise to 10,000 or even 15,000 per annum. We may yet live to see bulls, other than a small select aristocracy, become unwanted anachronisms. But that is not all. A cow normally produces only one ovum at each œstrum. When pregnant mare serum hormone is injected, however, she produces a number, as shown by J. Hammond, jun., and Bhattacharya at Cambridge. Attempts are now being made to transplant these into other cows—one into each—then to fertilize them by artificial insemination, and so get a dozen or so offspring from the chosen mother in place of a solitary calf. Scrub cows, otherwise of little use, could thus become incubators of the eggs of high-grade cows, the method would be particularly valuable for beef cattle. Already the transplanting has been successfully done with rabbits. No end is in sight: one cow could potentially produce some 75,000 ova during her lifetime. Nevertheless, there is always the lurking suspicion that Nature may resent being unceremoniously bundled out in this way; we can only wait and see.

For it is a fact that attempts to control natural processes without adequate knowledge are always risky and may be dangerous. So agricultural scientists have long aimed at knowledge rather than control, certain that if their knowledge is sound their control will be secure. In the great agricultural research institutions to-day ideas and equipment are freely borrowed from the pure sciences; in studying soils, plants, animals and their relations one to the other, use is made of modern biochemical methods, of physical methods, of X-ray photography, of the electron microscope, of tracer elements to follow the processes of plant nutrition and so on. There is inevitably a time-lag between the gaining of new knowledge and its possible use; for engineering Sir Richard Southwell puts it at fifty years. For agriculture it is less, and the Agricultural Improvement Council has been recently set up to keep it to a minimum. The Royal Agricultural Society has long been working to the same end.

I shall attempt no forecast as to how much food the earth could be made to yield. The limit at any time is set by the efficiency of the plant as a transformer of radiant energy; at present this does not exceed 5 per cent, and, reckoned on the basis of the amount of food produced, it is much less. Whether this can ever be raised, whether we can ever do more than increase the proportion of assimilation products useful as food, cannot be said. But the present limitations to food production: utilization of 7–10 per cent only of the surface of the earth; conversion by the animal of 10–25 per cent only of its food into human food; and fixation by the plant of no more than 5 per cent of the radiant energy it receives; these are all challenges to agricultural science—which its workers are vigorously taking up.

No limits can be set to the possibilities of science, but it does not follow that the present rate of advance will continue. Great scientific discovery is possibly only for the gifted few, and only in an atmosphere of complete intellectual freedom: subordination to political or any other dogma is utterly destructive. Nor can we praise the growing tendency to take good men of science out of the laboratory and put them into committee rooms, or to load them up with so much administrative and other detail—nowadays housework as well—that they lack the leisure for "reaping rich harvest from the mellow soil of quiet thought, mother of great deeds", to quote the noble words of Æschylus. Then there is the ever-growing specialization against which Sir Richard Livingstone and others are tirelessly warning us. The individual suffers: Whitehead reminds us that a man may know all about the laws of light and yet miss the radiance of the sunset and the glory of the morning sky. And the loss to science may be greater: the breadth of culture of some of our pioneers—D'Arcy Thompson, Percy Frankland, J. B. Farmer and others—had much to do with their breadth of scientific vision.

Nevertheless, remarkable success is attained by teams of highly trained specialists working under an inspiring leader—even when the team includes men who, by themselves, would easily become

"lost in a gloom of uninspired research",

as Wordsworth put it.

The possibilities of food production are, however, only part of the story. Food producers will labour to obtain a surplus for the outside world only on condition that they are provided with adequate appliances and incentives; and the replacement of craftsmanship by mechanization is inducing in agriculture, as in industry, a flight from labour. In many cases now the problem is not so much to increase output as to maintain markets and reduce hours of work. Happily, in spite of modern tendencies, a strong sense of individual responsibility in regard to hungry peoples still survives among food producers. This is, indeed, the basis on which Lord Boyd Orr built up the Food and Agriculture Organisation, now doing such useful work. But it would be entirely wrong to think of the world as a welfare State where food will be produced simply out of a sense of duty. If more food is needed, more work must be done to earn it.

The increased food production that may confidently be expected is more than ample for population increases at Western rates. But it could easily be outstripped locally where Eastern rates of increase prevail. A physiologically adequate dietary might still be attainable, but if Western standards of living are desired, Western restraints must be adopted.

These, however, are human problems, and, great as are the powers of science, it is of only limited help here. It can do much to overcome material difficulties and, better still, to satisfy man's thirst for knowledge of the universe in which he lives; and it can insist continuously on our high duty to seek out the truth fearlessly and honestly, and having found what we believe to be the truth, to proclaim it—but in all humility and recognizing that we may be wrong. Apart from that, science can give little guidance in those great moral and spiritual problems which lie at the root of our most serious troubles to-day. It opens up many possible ways of life, but gives no help in choosing which to follow; it deals with the facts of existence but not with the values of existence. It gives some light to them that sit in darkness, but it has little consolation for those in the shadow of death, and it does not guide our feet into the way of peace. Even if science should make large-scale fighting wars impossible, it can do little against the more subtle wars by infiltration. It offers us great

possessions, but as the old aristocracy knew, great possessions imply a sound sense of values and great personal responsibilities. Democracies still have this to learn. That is one of our greatest problems to-day.

But there is no need for pessimism. Looking back to the time of the first meeting of the British Association at Newcastle, one can find much ground for hope. Those, too, were days of terrible anxiety and strain, and yet there were then born many movements and activities which, scarcely noticed at first, blossomed later into full vigour, and greatly enriched our national life. How many important centenaries have been celebrated in the past few years. It may be that, unperceived by us, new movements are now starting into life, equally full of momentous possibilities for the future. Science can help us best if we have a sustaining faith, a high purpose in life and unflinching courage to pursue it.

SUMMARIES OF ADDRESSES OF PRESIDENTS OF SECTIONS

SOME DEVELOPMENTS IN ASTRONOMICAL INSTRUMENTS

SIR HAROLD SPENCER JONES opens his presidential address to Section A (Mathematics and Physics) by pointing out that, until far into the eighteenth century, astronomical observations were concerned almost entirely with the determination of the positions and movements of the heavenly bodies. In the seventeenth century the transit instrument became the standard instrument for the determination of right ascensions, while the mural circle was generally used for the measurement of declinations. Eventually the two instruments were combined to form the transit circle, which, with improvements in detail, has continued up to the present day to be used for the fundamental determination of positions. As requirements for precision have increased, its limitations have become more apparent. The errors of adjustment, continually changing with the ambient temperature conditions, are difficult to control accurately; complicated flexure effects, the error of figure of the pivots, and minute mechanical displacements in a telescope which is swung into different positions, introduce errors which are partly of a systematic nature and limit the accuracy with which a fundamental reference system of star places can be provided. Consideration is, therefore, being given to other designs of meridian instrument, likely to be less affected by systematic errors. In one of these the position of the instrument for each observation is determined by optical methods; in another the moving parts are reduced to a mirror, which can be turned to reflect light into one or other of two horizontal telescopes in the meridian, to the north and south of the mirror. For the determination of time, the development of the principle of Airy's reflex zenith tube to permit of photographic observations provides a much higher accuracy than is attainable with the transit circle.

The developments in physical astronomy have caused meridian instruments to be superseded almost entirely by equatorial telescopes in most observatories except the principal national observatories. The refracting and reflecting types of telescope have alternated in favour. In the seventeenth century the large aberrations of the primitive simple lenses necessitated telescopes being made so long that they fell into disfavour. Newton devised the form of reflector which bears his name, but the first satisfactory reflecting telescope of this type was made by Hadley in 1720, who took the essential step of parabolizing the mirror. Dolland's patent of the achromatic objective in 1758 brought the refractor back into favour, but the size was limited by the poor quality of the optical glass. William Herschel's success in making larger mirrors of speculum metal, and the excellent quality of his telescopes made the reflector more popular. But the need for frequent repolishing of the speculum mirrors, the inconvenience of the altazimuth mounting, and the better refractors that became possible through Guinand's improvements in the making of optical glass and through his collaboration with Fraunhofer caused an almost complete reversion to the refractor. The equatorial mounting was developed by Sisson, Ramsden and Fraunhofer, among others. There was a rapid increase in aperture of the refracting telescope from Fraunhofer's 9½-in. Dorpat refractor of 1824 to Alvan Clark's 40-in. Yerkes refractor of 1897. It had then reached the practicable limit in size, and it is unlikely that a larger aperture for a refractor will ever be attempted.

Liebig's discovery of a simple chemical process for depositing a film of silver on glass, together with Foucault's improvements in the methods of figuring and testing glass disks, caused attention to revert again to the reflector. The developments in technique due to Draper, Common and Ritchey made the modern large reflector possible. Its light grasp, its achromatism, and the ease with which it can be used at different equivalent focal lengths make it a much more general-purpose instrument than the refractor, the main purpose of which is now in precise measurements. The use of an aluminium film, deposited by vacuum distillation, has enabled spectrographic observations with the reflector to be extended to the limit of atmospheric transparency.

'Pyrex' glass, because it has a lower coefficient of expansion and a higher thermal diffusivity than plate-glass, is now generally used for mirror disks. The thinner the disk the more rapidly it will reach a state of temperature equilibrium; but then also the more flexible it is, the more elaborate the support system must be. Sagging of the disk under its own weight can be counteracted by a properly designed support system. Couder has derived criteria, based partly on dimensional considerations and partly on experimental results, from which the number of supports required for a disk of specified diameter and thickness can be estimated.

The principal defect of the paraboloidal reflector is the small angular field which is free from coma, seriously limiting its use for direct photography. It can be overcome by the use of a spherical primary mirror in conjunction with an aspherical plate in the plane of its centre of curvature, figured to correct for the spherical aberration of the primary. This arrangement, generally called the Schmidt camera after its designer, has effective radial symmetry and

gives a large field of sharp definition over a spherical focal surface the centre of which is at the centre of curvature of the primary. For investigations of stellar distribution, galactic structure, etc., it is unsurpassed. Used with an objective prism, it is ideal for the classification of the spectra of faint stars. There have been various modifications of the Schmidt design, such as the Schmidt-Cassegrain systems discussed by Linfoot, with which a large flat field of good definition can be obtained. For the Isaac Newton reflector at the Royal Greenwich Observatory, it is proposed to make the primary mirror spherical with a radius of curvature of about 50 ft. and to use it in conjunction with a Schmidt correcting plate for direct photography. In spectrographic observations, this plate will be removed and one of two or more aspherical Gregorian secondaries, corrected to give good axial definition, will be used, according to the equivalent focal length required.

Different types of mounting have been used for large reflectors: the German mounting; the simple English mounting; the English yoke mounting; and the open fork mounting. The 200-in. reflector at Mt. Palomar has a modified form of the yoke mounting, the upper bearing being in the form of an open horseshoe, enabling the telescope to be pointed to the pole. The fork mounting is in many ways the most convenient.

Many different instruments have been designed for special purposes in astronomy. Among these, one of the most important has been Lyot's coronograph, which has made it possible to study the sun's corona without a total eclipse of the sun. There have been important developments in details of design and construction, in methods of driving and guiding telescopes, in the design of spectrographs and other ancillary equipment. The design of almost every instrument presents special problems, and it is by the closest collaboration between the user, the designer, and the constructor that progress in observational astronomy can best be made.

COMBUSTION

As the background on which to develop the subject of his presidential address to Section B (Chemistry), Sir Alfred Egerton uses the records of the previous meetings of the Section in Newcastle. Whewell was president of the Section in 1838, Williamson in 1863, Lothian Bell in 1889, and Henderson in 1916. Sir Alfred directs special attention to the remarks of Sir William Armstrong, as president of the Association in 1863, on fuel economy, and to discussion in 1916 on the subject.

Omitting historical discussion of the influence of the early work on combustion on the birth of chemistry as a science, which has been a subject of earlier addresses to the British Association by Sir Edward Thorpe and others, Sir Alfred takes the work of Davy as having been the keystone of the particular field of combustion chemistry which still thrives. Davy, in his paper on combustion published by the Royal Society in 1817, described investigations on the limiting composition of combustible mixtures, observations on the structure and speed of flames, on the influence of inhibitors of combustion and on surface combustion, on the effect of pressure, the pressure developed on explosion which leads to measurement of flame temperatures, etc. Bunsen and his school developed Davy's work, and the knowledge gained had an influence on the establishment of the laws of thermodynamics and the development of physical chemistry. Combustion chemistry was further advanced by Berthelot's discovery of the detonation wave, and Mallard and le Chatelier's application of photography to the determination of the velocity of flames. These and other advances made by H. B. Dixon, W. A. Bone, A. Smithells and others, and by Haber, Nernst and others on the Continent, had their influence not only on chemistry, but also on technological progress during the period 1890–1920.

The study of combustion has had an even greater influence on the progress of chemistry since 1920; for in this latter period the study of gas reactions has led to a deeper understanding of the mechanism of chemical reactions, particularly in connexion with the combustion of phosphorus, of hydrogen and of hydrocarbons. Chain reactions provide an explanation for the limits of explosibility and for the behaviour of systems undergoing slow combustion, and the same notions have been applied to other problems which have had a great influence on recent advances, for example, the fission of atoms and production of new elements.

Sir Alfred refers to the conservation of fuel resources and their efficient utilization, pointing out the past wasteful methods of domestic heating. The possibilities in the development of gas turbines and distribution of energy in the form of gas produced by methods of total gasification are also mentioned. Looking back on the developments in the past fifty years, and bearing in mind the wonderful processes by which Nature synthesizes so many products, there is reason to believe that the achievements of chemistry will be no less great in the future.

RECENT WORK ON THE LOWER PALÆOZOIC ROCKS

In his presidential address to Section C (Geology), Prof. W. J. Pugh points out that the history of the Lower Palæozoic is the evolution of a geosyncline with its marginal shelf-seas, which extended from south-west to north-east across the western part of Great Britain. This prolonged period of marine sedimentation was accompanied by extrusive and intrusive igneous activity and was closed by the Caledonian mountain-building movements.

The Cambrian seas of the Welsh–Midlands region and of Scotland with their contrasted faunas were probably separated from one another by a land-mass which occupied the Irish Sea and adjacent regions. This land-mass was doubtless the main source of supply of the sediments which were deposited to the south and north of it; to the south, the thick development of North Wales, and to the north there may have been an equally thick development of comparable lithology since part, at any rate, of the Dalradian of the Southern Highlands is of Cambrian age. Geosynclinal conditions prevailed on each side of and adjacent to this Pre-Cambrian land-mass, while farther south and farther north, a smaller thickness of deposits accumulated in shelf-seas, although it is not known whether the Highland Border seas were continuous with those in the North-West Highlands. Movements of this Irish Sea geanticline controlled the characters of the sediments derived from it.

There were important earth-movements at the close of the Cambrian in the Welsh – Midlands region, involving uplift and erosion of the Cambrian sediments. These movements defined the limits of the Welsh geosyncline during the Ordovician, the margins of which lay approximately in Anglesey and in Shropshire. The Builth-Llandrindod inlier of Central Wales reveals an early Ordovician shore-line which is preserved with remarkable clarity, while dolerite intrusions of Ordovician age display laccolithic structures of unique types. The Ordovician rocks of the Lake District were deposited in the north-eastward continuation of the Welsh geosyncline; on the west, the St. George's Channel – Irish Sea area was geanticlinal, and to the east and north-east of Shropshire lay the main land-mass on that side of the trough. There was widespread volcanic activity as well as important contemporaneous earth-movements.

The Durness Limestone in the North-West Highlands must be referred mainly to the Ordovician, and while these calcareous rocks were being deposited, clastic sediments, accompanied by volcanic activity, were being laid down in early Ordovician times in the Southern Uplands, Girvan and probably the Highland Border. Then followed uplift and erosion in southern Scotland; but the facies distribution of the upper Ordovician suggests land to the north of Girvan, and the presence between it and the Irish Sea geanticline of a geosyncline, which continued south-westwards into Ireland. It would appear that the area north of the Highland Border was affected by these middle Ordovician movements, but it may also have been affected by those in the Cambro-Ordovician interval which were so evident in the Welsh–Midlands region. These earlier movements may possibly be responsible for the incomplete Cambrian succession in the North-West Highlands.

The Welsh geosyncline was maintained during the Silurian although there was a considerable change in the character of sedimentation, and in certain places uplift and erosion of the older rocks; but beginning with the Upper Llandovery and continuing throughout the Wenlock and Ludlow, the sea spread eastwards and southwards over areas which had been land during the Ordovician. There is evidence of the westerly derivation of material from the St. George's Channel – Irish Sea region; in Central Wales during the Middle and Upper Llandovery and in North Wales during the Wenlock and Ludlow; the Ludlow rocks reveal extensive submarine sliding and slumping of the sediments. The Welsh geosyncline still extended into the Lake District, but there is no evidence that the sea transgressed widely over the eastern stable area.

The Girvan-Moffat geosyncline persisted, and there are indications of an easterly derivation of material during the Upper Llandovery and Wenlock, suggesting separation from the Wales – Lake District trough; Ludlow rocks are only found in the Midland Valley, and it is not known whether they were deposited in the Southern Uplands.

The Downtonian rocks, which were deposited in basins and lagoons where at times conditions approached continental, are restricted to the south-eastern and north-western flanks of the Silurian tract. They may not have been deposited in the central region of North Wales, the Lake District and the Southern Uplands because it was being uplifted and eroded as a result of the onset of the Caledonian orogeny.

ZOOLOGY OUTSIDE THE LABORATORY

IN his presidential address to Section D, Prof. A. C. Hardy stresses the importance of zoological field studies. Ecology, by developing quantitative and experimental methods, is converting natural history into science. Its aim is not simply to express the inter-relationships of organisms with their environment in numerical terms—in itself a tedious refinement—but from such analysis to discover more of the laws operating in animate Nature.

It may seem strange that animal ecology should be so much more advanced in the hidden world of the sea than it is on land. We know more about the food relations of many fish than we do of any terrestrial animals. We have a better idea of the populations, per unit area, of different molluscs on parts of the sea floor than of the snails of our countryside; our knowledge of the numbers of small crustacea per cubic metre of water in many seas is far in advance of that regarding insect numbers on land. Possibly we know more about the ecology of the Dogger Bank and its overlying waters than about that of any English county.

We should not claim a greater marine enthusiasm. Of our food supply, the fish and whales are alone unfarmed and still hunted in the wild. It is, of course, the economic urge to find out more and more about them, so as to exploit them more efficiently, that financially has stimulated ecology under the sea. If only cattle and sheep had never been domesticated, what a wonderful series of terrestrial investigations we might have had by now, to enable us to conserve the stocks of wild game and use them to the best advantage. But is not ecology on land really just as vital—but not quite so obvious? While the main sources of our food are cultivated plants and domesticated animals, they are attacked by a multitude of wild pests. It is true that there are now dotted about the world many research stations, but most of these deal either with the control of certain pests, or with the biology of some particular kind of plant or animal. How many are devoted to the science of wild life for its own sake? At present very few. Yet it can only be through a better understanding of the basic principles underlying the complex interactions of wild life that really sound progress can be made towards a better knowledge of the factors governing our food supply.

That, indeed, is urgent; but such pure research in field zoology is important for a much more fundamental reason. Man does not live by bread alone—not man as most of us respect him. If he does come so to live—and it is a possibility—our civilization will change. Who can doubt that the roots of the two World Wars were not nourished to a large extent upon a philosophy of materialism and too small a knowledge of the working of evolution? If we could spend upon fundamental biology half as much as we spend upon research on atomic energy, how much more we would know about the very nature of life and the process of evolution. The study of evolution in action is one of the most exciting themes in ecology, for many of its problems can only be solved outside the laboratory.

We want more evidence in quantitative terms of the actual operation of selection in Nature. Are the very small isolated populations in which genetic drift can give rise to non-adaptive variations really important? Can they usually survive for long enough

to provide in time the pre-adaptive forms which may take advantage of some new situation in the changing environment? A still more important contribution that field zoology can make to evolutionary theory is to throw more light on the part played by organic selection. The gene combinations which are best suited to the *habits* of the animal may tend to survive in preference to those which do not give such full scope to the animal's pattern of behaviour. This idea, put forward independently by Baldwin and Lloyd Morgan at the turn of the century, may, indeed, be a factor of importance.

There has now appeared over the horizon something which many do not like to look at, namely, telepathy. Prof. Hardy believes that no one who examines the evidence with an unbiased mind can reject it; particularly the evidence from many experiments (made by several independent workers) which have passed the statistical tests regarded as decisive in normal scientific technique. Such a discovery should make us keep our minds open to the possibility that there may be so much more in living things and their evolution than our science has hitherto led us to expect.

THE PLANNING OF LAND USE

THE development of geographical thought over the past half-century has been marked by the emergence of a logical pattern of cause and effect and by the demonstration of the influence of environmental factors on human life. Prof. L. Dudley Stamp points out, in his presidential address to Section E (Geography), that the stage has now been reached when geographical methods of survey and analysis, and further, of synthesis, can be and should be applied and used so as to assist in the solution of the great social problems of the world to-day. In particular, in the field of land-use planning, there is considerable justification for the assertion that geography is the science of which land planning is the art.

Every country has two ultimate assets—its land and its people. The planning of land use is no more and no less than planning for the full development and use of natural resources, notably of food-producing land. It must be viewed against a world background of expanding population but fixed land area, where there are no longer vast tracts of virgin land available for easy conquest, even though the tropical lands are eventually brought into full production. Good land is becoming rapidly scarcer, and modern land planning involves a balance between competing demands. Land is needed for at least six basic needs of man: for the siting of industrial works, for homes, for food and associated raw materials, for recreation, for communications, for security or defence. The problem of securing a just balance between these competing demands is acute in a country such as Britain with only a little more than an acre per head—less than half an acre of food-producing farmland. Although a multiple use of many types of land is possible and a concept of 'optimum use' for any given tract may be developed, the old conflict between different interests may even be intensified under the comprehensive national land-use planning to which Britain is committed. The long-term advantage to the country of conserving the best food-producing land may conflict sharply with short-term economic advantages.

The most serious aspect of land planning to-day is that much is being done by those concerned with the day-to-day work of town and country planning without an adequate understanding of the scientific background, while far too often the essential facts remain unknown. A good example is afforded by the present chaotic state of 'rural planning'. Stated simply, increased technical efficiency in agriculture permits the maintenance of a high level of production with a smaller labour force. Even when agricultural production is increased, heavy rural depopulation is still in evidence. With a changing age-composition of the population, the stage is soon reached when the village communities dependent primarily on the land are too small to justify the continuance of a school or the maintenance of those services regarded as essential to a modern standard of life. For example, whereas an average rural parish on good farmland such as may be generally found in the English Midlands had 80 children between five and nine to support the village school in 1871, the number to-day is not likely to exceed 34. Instead, therefore, of restricting housing in the village to workers connected with the land, an active policy of encouraging others to go and live therein appears the only hope of maintaining corporate rural life.

A gulf exists between the natural scientist and the professional town and country planner. Sometimes it is a failure of the latter to use and apply existing knowledge; often it is the failure of the man of science to carry out those particular studies which are most needed. The geologist has not yet provided a drift map; the geologist shows little interest in the lithological characters which determine whether a given deposit—for example, of gravel—is or is not of economic importance. There is no soil map of Britain, and the trend of pedological research often renders modern work of less practical value than the pioneer studies of Hall and Russell. A comprehensive survey of water resources, so long urged by Capt. W. H. Mclean before the British Association, is still an outstanding need. The value of given tracts of land for such purposes as intensive horticulture frequently depends on microclimatology; yet there are few exact surveys to help the planner. Vegetation cover is accepted as an index of the sum total of environmental factors; yet ecologists have made little effort to produce a primary vegetation survey. Until some of these gaps are filled, the work of land-use planning must rest on a scientifically unsatisfactory basis.

In an old-settled country such as Britain, existing land use reflects the results of many centuries of trial and error—often the results of the interaction of geographical, historical and economic factors. The mapping and interpretation of the existing land-use pattern are fundamental contributions of the geographer to planning. Treated historically, the evolution of the pattern shows trends in development or change, and land planning is simply the encouragement of such trends or positive action to change them.

The vexed question of land classification calls for the evaluation of many factors. This is well seen in the determination of the ten types made by Prof. Dudley Stamp as director of the Land Utilization Survey. Although giving a crude and highly generalized picture, the Land Classification Map of Britain (now published by the Ordnance Survey for the Ministry of Town and Country Planning on the scale of 1 : 625,000) does serve to indicate the distribution

and small extent of the most productive lands of Great Britain, and points to the tracts which should be avoided in the siting of new towns if the productive capacity of the country is not to be impaired. The classification of land, when linked with the results of the Farm Survey (1941), suggests problems of the 'carrying capacity' of land in terms of primary producers, and so the population density to be expected with a given type of land and a given type of farming. Britain exhibits a curious super-imposition of an urban-industrial settlement pattern on an earlier rural-agricultural pattern. It may be suggested that many features of the latter are relatively permanent —the spacing of farm and village—whereas the former is changing and developing with new concepts of the standard of living and threatens to overwhelm the whole.

ECONOMICS : YESTERDAY AND TO-MORROW

SIR ALEXANDER GRAY'S presidential address to Section F (Economics) provides a survey of recent and current trends in economics. He points out that it would be possible to learn much about the continually changing view of the subject-matter of economics by reading in chronological order the definitions of economics given by its leading exponents. In Adam Smith, it was considered "as a branch of the science of a statesman or legislator". In the early part of the nineteenth century (as exemplified by Senior) there was a conscious effort to transform economics into a wholly independent scientific discipline, establishing laws or generalizations, while remaining perpetually and eternally neutral in a world of conflict. Broadly, the nineteenth century was in the main a period of specialization, when the economist tried to keep himself to himself, and to pursue the peculiar problems of his own specialism.

To-day the old frontiers have largely been obliterated; and perhaps in the next generation the economist's primary task may be to view his economics in relation to all the other so-called social sciences, and thereby to effect a new synthesis. The first and most complete disappearance of a frontier is that between economics and politics. To-day every economic problem has become a political problem; and most, if not all, political problems have their economic penumbra. So, also, it may be said that a structure of economic theory that is not based on a sound psychology is a house without foundation; and therefore your economist must be a psychologist—of a sort. Economics, in its modern form, sprang from the moral philosophy class-room of Adam Smith. Economics, in a familiar phrase, is the 'handmaid of ethics', and it is, indeed only in so far as we take some part in the ethical debate that our economics can acquire a meaning, an inspiration and a driving force.

The breakdown of the frontiers is accentuated by the fact that to-day the economic problems to be solved present themselves inextricably embedded in a whole mass of relationships which cut across purely economic considerations, and involve all phases of the manifold problem of men living together in society. It does not follow that we must cease to be economists; but more than ever, an economist, to be an economist, must be vastly more than an economist.

It follows, also, that in the near future there may be more urgent tasks for the economist than the elaboration of theory far above the heads of all but the experts. Never was there a time when so many experiments were being launched in the economic laboratory. Never was there a time of such far-reaching institutional change; and perhaps for the next ten years we may be constrained to revert, somewhat but not overmuch, to a point of view resembling that of the Institutionalists.

The economist of to-morrow will be living in a very different economic climate from that of nineteenth-century Victorianism, and the economico-political problem (of how to live together and keep things going) may be very different. There are three ways in which we may manage to live together in the complete Welfare State. The first is that of relying on a degree of compulsion vastly greater than we have yet had the courage or the honesty to admit may be necessary. If, disliking the idea of a world resting on compulsion, we ask for an alternative which will preserve our free society, the second possibility is to consider what can be done towards a solution of the age-long question of incentive. It remains true, however—and regrettably true—that the only effective incentives are of a material character, with an appeal to the individualistic and competitive instincts of mankind which we are supposed to be eradicating. If compulsion is rejected as immoral, if incentive is looked upon as a species of bribery, leading back to what some would regard as the jungle of individualism, there remains the third possibility of enrolling ourselves (for this purpose) among the followers of Lenin, and waiting in faith for the emergence of a better form of man, for the universal prevalence of a higher order of morality than that now to be found among us.

BRIDGING THE GAP BETWEEN SCIENCE AND INDUSTRY

THE theme of the presidential address by Sir Arthur Fleming to Section G (Engineering) is that industrial research and development form the bridge between scientific discovery and its practical application. Past technological achievements were obtained by the patient and persistent work of inventors and industrialists based on fundamental discoveries of scientific men. Such discoveries will always be the starting point; but to-day, as well as providing new ideas, science must also at every stage provide the means whereby their industrial application can be most completely achieved.

The function of industry is to make natural resources available for the use of man. Industry is dependent on engineering for power, machinery, transport and communications. It is never static, but its rate of progress depends on the acquisition and effective use of new knowledge. To-day new industrial knowledge is mainly derived from organised scientific research and is the result of team-work.

Facilities for pure research are expanding in university, Government and industrial laboratories and in research associations, but the cost is becoming increasingly heavy, especially in the field of nuclear physics, and this emphasizes the need for co-operation to avoid duplication of effort and waste of personnel. Further increased facilities for research are needed, but there must always be a balance between the cost of research in money and personnel and national

economy. The loss is serious if the results of research are not fully used, either through lack of trained personnel able to assimilate and implement new ideas, or through fear of risking capital in new ventures.

The stages in turning scientific knowledge to industrial account are well known. The first stage is carried out by industrial research, which requires laboratory facilities and trained personnel able to interpret the significance of scientific discoveries in the light of possible industrial applications. The next stage is to determine marketable possibilities, and the staff concerned must have commercial experience as well as scientific knowledge. The project then goes into commercial production, and the same team should see it through the difficult transition period until it is accepted into the orthodox manufacturing programme. The product and its production must then both be kept up to date by continued research.

The economic importance of reducing the time-lag between the discovery of a new idea and its ultimate industrial application cannot be over-stressed. Another important factor is the training of personnel. Training schemes for all grades of engineers exist, but particular attention should be given to the education of industrial research workers, development engineers and higher management executives. In the past, few industrial executives have received a scientific education. This, however, will be remedied in the future as a greater proportion of young people are taking science courses at school and university. Teaching staffs of the universities and technical colleges should be kept abreast of industrial practice by refresher courses in industry, and more attention should be given to the problem of making available to professional engineers technological knowledge which is too new to be included in a normal curriculum.

An outstanding example of bridging the gap between scientific discovery and industrial application is afforded by the production of the atom bomb, the starting point of which was the discovery of the electron fifty years ago. Fundamental research in atomic structure led to the discovery of the means of producing nuclear disintegration. Then followed the discovery of uranium fission and the chain reaction, which enabled the release of a vast amount of energy from the nuclear disintegration of the uranium-235. Carrying this discovery into effect involved extensive research activities in physics, chemistry, metallurgy and electrical engineering, and led to the construction of plant and equipment on an unprecedented scale. The eventual results are well known. Post-war research on this subject is being pursued in the United States on a large scale in Government, university and industrial laboratories. Though primarily conducted from the point of view of national security, it will ultimately produce knowledge of great benefit to mankind, and the United States will have a great number of scientific men trained in the practical application of nuclear physics and able to turn to industrial account new discoveries made in this field.

Our economic needs and the demands of national security emphasize the importance of utilizing science. All our assets of skilled personnel and knowledge must be fully used, and more co-operation between industrial and Government laboratories is essential to employ our scientific personnel to the best advantage.

PLACE OF ARCHÆOLOGY IN NATIONAL EDUCATION: A SURVEY AND A PLEA

MR. M. C. BURKITT'S presidential address to Section H (Anthropology) has two main themes running through it. While the foundations of studies in prehistory have been well and truly laid, there are a number of general problems in the subject which remain unsolved and some of which are touched upon in the course of a survey of the periods. For example, why is it that from the material point of view the evolution of the stone industries in widely separated areas of the world follows the same pattern, though the cultures concerned may have little or no apparent link with their counterparts in the various regions? Core-tool industries are almost everywhere succeeded by others made essentially on flakes, and these in turn are followed by industries made on blades, and these again by pigmy tools, with finally the appearance of a new technique for tool-making, namely, that of grinding and polishing. Yet there is no reason for thinking that, for example, the flake-tool industries of Western Europe—the Levalloisean, Clactonian or Mousterian—had any physical links with the great Middle Stone Age complex of South Africa, the flake-tool industries of which are in part, at any rate, evolved from the earlier core-tool industries of the region. The situation is different for the core-tools themselves, where it seems that some contact must be postulated. Some stress, too, is laid on problems of cave art and of the multiple origin of the Aurignacian culture in Europe. Coming to the Neolithic Age, the effect on human ideology of the discoveries of agriculture and the domestication of animals is considered. The material changes resulting are, of course, well known. But the effect of these new discoveries on the outlook on life of the early food producers has not been so carefully considered.

The other main theme which is worked out concurrently by Mr. Burkitt is a plea that the study of early archæology shall be considered for the curriculum of secondary schools in Britain. Since the present time is a period of flux, it is not inappropriate to examine whether some of the subjects now included are any longer very useful. From the grammar and public school points of view, intensive algebra and Latin verses would seem to have outlived their usefulness, except to the specialist, and any purely mind-training qualities these subjects possess can be found in other more useful and interesting studies. Even in secondary modern schools, some of the subjects taken by the older children in the 'A' streams are not particularly useful or thrilling. On the other hand, prehistoric archæology has much to commend it. The methods employed are strictly scientific and logical, and many of them—such, for example, as the stratigraphical law of superposition—can be demonstrated practically. Yet the study is of humanity and deals with our own origins. Again, while there is much of a general nature to learn, there are also many detailed practical considerations to deal with. There are youngsters who can realize and enjoy the general sweep of events, whether in prehistoric or historical times. Others somehow cannot imagine the general, and are attracted by the detailed and particular. For such the study of technology and typology would at any rate be more exciting than algebra, and equally useful for mind training.

We live in an age when democracy is ever demanding shorter working hours. Are we giving our young people hobby subjects to occupy the resulting

increased leisure time? Much has been done in the realm of the crafts. Both at school and later in the youth clubs, craft work looms large in the programmes. But not everyone wants to work in plastics or to make lamp-shades. A few intellectual hobbies are urgently needed. These, however, require a little preliminary knowledge. Why not, then, kill several birds with one stone? Substitute for some of the useless subjects now taught one which is equally useful as a mind trainer, which will fascinate instead of bore the pupils, and which will in some cases at any rate start a life-long interest in a delightful hobby subject that can be enjoyed until old age wherever the individual may happen to live, being also an objective for innumerable holiday periods, and which may have a profoundly stimulating philosophic influence on the thoughtful mind.

BIOCHEMICAL AND BIOPHYSICAL ASPECTS OF THE CELL

THE presidential address by Prof. R. A. Peters to Section I (Physiology) is concerned with the biochemistry and biophysics of the cell, and forms the introduction to a series of addresses upon nucleoproteins by Prof. J. N. Davidson, upon lipoproteins by Prof. A. C. Frazer, upon cell structure by Dr. R. Barer and upon sea urchins by M. Swann. The subject is approached from the standpoint of pharmacology, and is thus in line with that given by Cushny at Newcastle in 1916.

Prof. Peters deals with advances in biochemistry particularly from the point of view of organisation of enzymes; though a purely scientific subject, it must be remembered that theoretical studies of this type formed the background to the development of British anti-lewisite. The two simple halogen substances, sodium monoiodoacetate ($CH_2I.COONa$) and fluoroacetate ($CH_2F.COONa$) are both very toxic to higher organisms. Fluoroacetate, unlike iodoacetate, is found in Nature, having recently been proved to be the toxic principle of a very poisonous South African plant (Gifblaar or *Dichapetalum cymosum*), the toxicity of which to cattle has been a problem to South African farmers. As little as ½ oz. of the fresh leaves may kill a sheep, and of fluoroacetate itself 1 mgm. will usually kill a 200-gm. rat. Convulsive signs or heart attacks predominate in different animals. There is a suggestion that other species of the genus have been used for poisoning wells and similar nefarious purposes. Considering the biochemical analysis of the toxicity, iodoacetate is toxic because it combines with the sulphydril (SH) groups of cell constituents; it thereby blocks the activity of enzymes the effects of which depend upon sulphydril groups; in this it resembles the trivalent arsenicals, though its action differs in detail. Speaking generally, the cell enzyme most sensitive to iodoacetate is the triosephosphate dehydrogenase; hence the poison blocks the supply of energy from carbohydrates in the early stages at the triosephosphate level, thereby interfering with cell function. There are now several proofs of the dependence of cell activity upon the action of some one enzyme or enzyme system; the single deficiency of vitamin B_1–pyrophosphate in the central nervous system induces convulsions.

Differing from the iodo compound, the C—F bond in fluoroacetate is too stable to combine by substitution with sulphydril groups. Both *in vitro* and *in vivo*, this poison causes an accumulation of citrate which is especially marked in kidney, heart, spleen and brain. The formation of citrate can be explained by modern biochemical conceptions of organised enzyme systems. A central enzymic mechanism exists, known as the tricarboxylic acid cycle, which induces oxidation of final 'two-carbon' fragments formed in the metabolism of carbohydrate (or of fat); the oxidation takes place by the initial step of condensation of the 'two-carbon' fragment with the four-carbon acid oxaloacetate to form a six-carbon acid in the citric series. The 'citrate' is eventually degraded. The formation of citrate *in vivo* by the poison can be explained upon the hypothesis that the fluoroacetate is activated like acetate, and after formation of a six-carbon fluoro acid, this latter 'jams' the tricarboxylic cycle. This plausible explanation of a mysterious poisoning gives some insight into the progress of modern enzyme biochemistry and constitutes evidence of the physiological reality of biochemical schemes.

Inquiries into the site of these enzyme complexes in the cell suggests that they may be present in the cytoplasmic cell inclusions, the so-called 'granules'; the cytoplasm has attained greater significance with the modern finding of nucleoproteins in it as well as in the nucleus. Consideration of the prominent features of cell life leads to the view that the cell is organised as a whole; different reactions must be capable of proceeding simultaneously and the cell itself capable of reacting as a whole to external stimuli applied to a small part of the cell surface. Surface structure, both internal and external, seems to dominate the cell. The microheterogeneous nature of the structure based upon a cytoskeleton, together with calculations of the volume of water dissociating one hydrogen ion at neutral *p*H, and the effect of killer agents in paramœcin, lead to the view that a chemistry not based upon ordinary mass-action laws is in operation in life. Though progress must be slow due to the complexity, an optimistic view of future advances is taken by Prof. Peters, owing to the increasing interest of pure chemistry and physics, and to the very powerful tools now available. It will probably never be possible to dispense with those whose special function is to study life. The relation demonstrated between the South African plant poison and modern biochemical work on enzyme systems illustrates the unity of Nature.

NATURE OF THE MIND'S 'FACTORS'

THE presidential address to Section J (Psychology) by Sir Godfrey Thomson is devoted to a critical consideration of certain logical weaknesses in the usual methods of factorial analysis, and in particular of the custom of magnifying specific factors by the use of minimal communalities in the diagonal cells of the table of correlations or covariances, a custom defended in the name of parsimony of factors. "My general attitude to factors," Sir Godfrey says, "is that they are vivid additions to our vocabulary, but that there is a danger that they may be looked upon as much more real and individual mental entities than they actually are. They are, in my opinion, not at all unitary and only partially innate, being to a very considerable extent, as I think, built up in the individual mind by many external influences."

Factorial analysis requires the co-operation of mathematician and psychologist, who must endeavour to understand one another. An illustrative model is described in which standardized tests are represented by lines at angles the cosines of which equal the correlation coefficients. The population of persons can then be represented by the points of this n-fold space, the density contours of which will be spherical. The problem of factorial analysis is to decide on a set of axes to describe this space. The test vectors are not spread over the whole space but are in a double cone the extreme edges of which are at about 90° with one another, for few correlation coefficients are negative.

The mathematician naturally uses orthogonal axes and usually puts the first one down the centroid of this cone, the later ones sticking out into the equatorial region where there are no real tests. He is willing, however, to rotate these axes to other positions, among which the psychologist must choose. The latter explains that he wishes to have his factors where they can be approximated to by real tests. In his words, he wants to find 'pure' tests of each factor. Since this is manifestly impossible in the case of axes sticking out into the equatorial region where there are no real tests, some rotation of the centroid axes is imperative. American psychologists confidently rotate them to enclose the double cone of real test vectors, and if necessary they close them up on that double cone so that they become oblique. British psychologists cling to orthogonal factors and only rotate them as little as possible, retaining the first factor not very far from its centroid position.

The psychologist has, however, another condition to lay down, and it is this which Sir Godfrey chiefly criticizes. He wants to have as few *common* factors as possible, and to reach this he allots to each test, at the very outset, as large a specific or unique factor as the mathematician can allow, without giving any psychological consideration to the question whether such specific peculiarities are likely in the tests. This is done by inserting minimal communalities in the diagonal of the matrix of correlations, reducing it approximately to a low rank; this procedure results in using *more* factors than there are tests, when we include the specifics, so that all the factors are outside the test space. That this can be done may be due to a mathematical property possessed by a large number of small causes of which each test draws on a sample, probably a different sample in different individuals. The tests undoubtedly act *as if* there were a small number of common factors and large specifics, but it does not follow that they are really thus constituted. Just as a large number of small causes in a linear measurement can produce a Gaussian distribution, so a large number of small causes of which overlapping sets or samples are taken will produce correlations which could have been produced by a few common factors and large specifics, but need not have been thus produced.

In conclusion, Sir Godfrey uses a humbler analogy: "Suppose that three street collections have been made, producing £200, £300 and £400 respectively. There might have been one general contributor who gave £100 to each charity and three specific contributors who each made up the balance of one charity. The hypothesis is in entire agreement with the facts; but actually it is much more likely that dozens and hundreds of people gave their mites, some to one only, some to more than one; and so, I think, it is with the correlations between tests."

UTILIZATION OF SEAWEEDS THROUGH THE AGES

THE macroscopic marine algæ fringe the rocky shores of the lithosphere and extend into the adjacent comparatively shallow water. They were used by coast-dwellers from very early times for a variety of purposes; but the quantitative curve of utilization has altered periodically and must be viewed against a background of economic history if its changing form is to be fully appreciated. In 1949 a rise in the curve has occurred and seaweed products are available even to inland populations. Prof. Lily Newton, in her presidential address to Section K (Botany), therefore, reviews the earlier history of algal utilization and suggests some lines along which future work can best be directed.

Though it is evident that a section of the community in the Western world has despised these denizens of the shore and shallow seas, their usefulness as human food, cattle fodder, in agriculture, in medicine and as a mordant in dyeing was known before the birth of Christ. Cattle have grazed on the seaweeds from time immemorial, and as the art of crop husbandry spread from the plains of Asia all over the world, marine plants, wet, dried or burned, were used increasingly for manure.

The next phase of the seaweed industry, the extraction from the algæ of soda, potash and iodine, was centred in western Europe. From the large brown algæ which were burned to form kelp, crude soda was obtained for the glass and soap industries. This trade reached a high peak of prosperity during the American War of Independence and the Peninsular War, and on account of the timber famine in Europe which removed a former source of alkali. The subsequent decline in the industry was due to the lowering and repeal of the salt tax, the discovery of the Stassfurt mineral deposits and the introduction of the Le Blanc process for the production of soda from common salt. A revival of the trade in kelp occurred during the Napoleonic wars, when the brown seaweeds proved an important source of potassium for making gunpowder, and a new substance, iodine, was discovered to be present in them. E. C. Stanford introduced new manufacturing processes, and improved methods which benefited the industry for some time, but the final blow to its fluctuating fortunes in Europe was dealt by the discovery that iodine occurred as iodate in the crude nitrate of soda deposits of north Chile. During the latter part of the nineteenth century, when there was a temporary rise in the price of potassium salts and iodine, Japan and the United States began to produce kelp from Laminarias, *Macrocystis* and *Nereocystis*. Sweden, Canada and Russia have also taken some part in the kelp trade.

In 1884 Stanford announced the isolation from brown seaweeds of algin, which he later called alginic acid. This discovery marks a change of emphasis in commercial production from inorganic to organic substances. Research on the seaweeds yielding alginates, on methods for their location, often in relatively deep water, on methods of harvesting and on the utilization of the products, is in progress in Great Britain, the United States, Australia and elsewhere.

In the Eastern world, the Chinese and Japanese have used seaweeds in a variety of ways, in agriculture, horticulture, in medicine and pharmacy, in making adhesives and plaster boards, inorganic substances and alginates; but it is as human food that marine

plants have been most important in oriental economics. Among the most important products is agar, which can be made from a number of red seaweeds. In addition to its use as food, agar has come to be indispensable in the textile and leather trades, in making high-grade adhesives, photographic films and shatterproof glass, in medicine and pharmacy and as a medium on which fungi and bacteria can be grown. It is an essential product in all scientific laboratories for culture work, and during the Second World War it was imperative that all countries should have a sufficient supply for the preparation of protective vaccines both for the civilian population and the armed forces. The need was met in different countries in a variety of ways. In Britain an excellent agar was made from two red seaweeds, *Chondrus crispus* and *Gigartina stellata*, known collectively as carrageen; these seaweeds were located and harvested mostly by enthusiastic voluntary labour.

Co-operation is needed not only among research workers in many branches of science but also between scientific workers and the commercial world if the best use is to be made of the vast potential resources that are being rhythmically and unceasingly produced in the waters that surround our shores. The work of the surveyor, the engineer, the economist and the manufacturer must be based on the sure foundation of the detailed study of the plants themselves if it is to stand effectively.

THE WIDENING SCOPE OF THE STUDY OF EDUCATION

IN his presidential address to Section L (Education), Sir Fred Clarke remarks that it is now better understood how we have reached a stage where education has become a major instrument of national policy. Some light is thrown on the matter, so far as Great Britain is concerned, by a glance back over the last two centuries or so. Two phenomena are particularly noticeable: first, that in both content and methods education was overwhelmingly a matter of tradition; and second, that the golden age of liberalism was also an age of maximum security.

In spite of some variants and breakaways, tradition still ruled even after education had ceased to be selective and had become compulsory for all alike.

The liberalism of the nineteenth century brought less change in this than might have been expected. But it did bring two important contributions. One was science, the other was the idea of the autonomous, self-sufficing individual.

The introduction of science into the curriculum was slowly achieved and very soon it, too, tended to fall under a tradition of its own. Perhaps more important was the application of scientific methods to the study of education itself, and particularly to problems of child-care and teaching.

A growing body of knowledge was the result. But, until recently, the 'individual' was still conceived too abstractly, and the studies took little or no account of the profound changes in social and cultural environment which even then were exerting such influence both upon the growing child and upon his teachers. Persistence of the nineteenth-century notion of the individual is insufficient to account for this. Society and its influences could be so taken for granted because of the peculiar conditions of security that the century enjoyed.

Two influences in particular helped to bring about the changed outlook of our time. One was the thrust of the working-people for wider opportunity, affecting education as it did. The other was that increasing concern for the national future which became so marked towards the end of the century, particularly among the governing classes. It was, perhaps, a fortunate thing that these two influences tended to the same result, an increased concern for general education and a heightened sense of the historical and sociological factors which determined educational thought and practice. Thus there can be little doubt that many of the studies now undertaken were influenced by consideration of the needs of the elementary school, to which the great majority of the population went. The transformation of the elementary school during this century is an achievement that owes much to the new outlook.

To-day we are reaching, if we have not already reached, a conception of education for which little or nothing in the life of society is wholly irrelevant. Studies have broadened out accordingly, and the lengthening of the period of organised educational care has contributed to the same result. Psychology, for example, is concerning itself more and more with the characteristics of adolescence, and social psychology has come into its own.

To illustrate the kind of provision for which this broadened outlook calls, the example of arrangements in the University of London may be cited. At least five essential professorial chairs are now established, each representing a distinct line of approach. These are: philosophy (the most fundamental of the studies), psychology, history, sociology, and comparative education. As provision along some such lines as these is made in the new university institutes of education throughout Great Britain, it may be expected that stimulating and bracing influences will be brought to bear both upon the work of the schools and upon the training of young teachers for work in them.

If there is any danger that studies may become too detached from actuality, too purely theoretical and self-absorbed, we may hope that the play of informed critical opinion, coming mainly from the schools and colleges but also from an interested public, will supply the necessary corrective.

FARMING, SCIENCE AND EDUCATION

PROF. N. M. COMBER, in his presidential address to Section M (Agriculture), first deals with the lost appreciation of the status and prestige of farming. In peace-time and times of plenty, the majority of people use their food not merely as necessities of life but also as tokens of goodwill and friendship. Men do not dine together for merely utilitarian purposes; but they are largely oblivious to the reason why the products of the farming industry are used (as the products of no other industry are) to betoken the spiritual as well as the physical well-being of mankind. In times of war, when all minds are on farming, it is the necessity and not the glory of farming which is brought home to everybody. At no time, therefore, in the modern era are the majority of people able to appreciate the status of farming, which lies in the fact that it is inextricably connected with the status of human life itself and is fundamental in a way that no other industry is. In the midst of

all the divergent opinions about the origin of human life, it has to be agreed that whatever the amount of divine authority by which men were created to be men, they were commissioned to be farmers by exactly the same amount of authority. Farming is all the time a fight against Nature, which itself does not provide human food, and it is in pursuing this life more than in any other way that the high qualities of human character have been developed.

Coming to the application of science to farming, Prof. Comber stresses that farming must always be fundamentally an art and a craft. It has worked for untold centuries, with no scientific knowledge of it until a little more than a century ago, and how it works is still only very partially understood. Agricultural science is still only young and immature compared with the industry of farming itself, and taking the long view it is a good thing that the introduction of science into farming has had to contend with criticism and opposition.

It is in the nature of things that the successful teaching of agriculture is dependent upon the teacher's personal experience in the industry, and no one reading a text-book of agriculture can be unaware of the fact that farming cannot be taught by book. Because of this the association of advisory work (with its personal experience of farming problems) with teaching institutions was invaluable, and the separation of this advisory work from teaching centres in 1946 is to be deplored more than anything in the history of agricultural science in Britain.

A little more than a century ago scientific knowledge and understanding of crop and animal husbandry were almost non-existent. At that time the need for new knowledge was paramount. That, however, is not the position to-day. The limiting factor now is the education of people going into the farming industry. This need differs from the need of education in almost every other industry because of the fundamental character of farming. There are people who are manifestly born farmers who could not easily make a success of any of the existing types of courses, and there is need for special informal and, some may say, unorthodox types of courses for those people with a strong practical aptitude with no conventional appreciation of science. Educationists cannot prescribe the qualifications of farmers as they can those of other industrialists.

Finally, Prof. Comber urges that there is too much confusion and blurred overlap between college courses leading to diplomas and university courses leading to degrees. It is high time that the existing subject-matter be used with a full realization that in twenty years a lot of it will be out of date and subject-matter hitherto unknown will have arisen : it is time that it was realized that education is the training of personal qualities and that in the agricultural degree courses a large amount of what is supposed to be utilitarian matter is suppressed to make place for philosophical and cultural subjects (along with agriculture), and to make place, too, for time in which undergraduates can engage in university life.

THE PRESERVATION OF NATURE

SO great has been the advance made recently in Great Britain and abroad in the recognition of the need for the preservation of Nature that it is opportune to look back on the course of events. Dr. G. F. Herbert Smith points out in his presidential address to the Conference of Delegates of Corresponding Societies that it needed a tragic war to make urban dwellers realize that food did not automatically arrive in the shops. The problem of the best use of the land in a small and crowded island like Great Britain is difficult. Care should be taken to assure that in new schemes nothing of scientific importance is destroyed ; in this respect local societies can render valuable assistance.

Although we know that species of plants and animals have come and gone, it is only during recent centuries that their extermination has been due to man. Until he acquired weapons and machinery, he did little harm and fitted in with his environment. The earliest loss to attract general attention was the large and clumsy bird, the dodo. The bison in America and in Europe was only just saved, almost at the last moment. National parks, which safeguard scenery and wild life, while providing ample opportunities for recreation, originated in the United States and have spread all over the world, and they have been accompanied by the smaller areas known as Nature reserves. Even in Britain, thanks to the activities of various societies, Nature reserves have been established, and a welcome feature has been the development of local naturalists' trusts. In 1941 a conference met to consider Nature preservation in post-war reconstruction, and from it the Nature Reserves Investigation Committee arose and made a careful natural history survey of England and Wales. Its two reports appeared in 1945, just in time for the use of the Wild Life Committee appointed by the Ministry of Town and Country Planning. The report of the latter was published in 1947, together with a similar, but less complete, one for Scotland. As the result, the Government established the Biological Service, with the Nature Conservancy to supervise it. The National Parks and Access to the Countryside Bill now before Parliament has a section dealing with Nature conservation.

International co-operation to any general extent began with whales, and various regulations have been agreed to, but are not completely successful in the absence of policing. A flourishing International Committee for Bird Preservation has been established by private effort, and has sections in thirty-five countries. The general movement to encourage the protection of Nature began about 1905, and progressed as far as the establishment of an International Advisory Commission in 1914 ; but the outbreak of war prevented it from functioning, and it was never revived owing to the political difficulties after the War. Following upon the International Congress at Paris in 1923, an attempt was made to form an international committee ; but the time was not ripe, and only the International Office for documentary purposes resulted. After the Second World War, the Swiss League for the Protection of Nature convened in 1947 an international conference with the object of reviving the International Advisory Commission of 1914. It was, however, decided to ask Unesco to summon an official conference in 1948 with the object of establishing an International Union for the Protection of Nature. The Union was duly established, with its seat at Brussels. It may be anticipated that its attention will be devoted mainly to the preservation of Nature and not merely to the safeguarding of species threatened with extermination. The relation of the size of the population to food supplies may present a difficult problem.

OBITUARIES

Sir Frank Stockdale, G.C.M.G., C.B.E.

THE sudden death on August 13 of Sir Frank Stockdale at the comparatively early age of sixty-six came as a shock to his numerous friends and removed one who occupied an outstanding, indeed almost a unique, position in Colonial affairs.

Frank Arthur Stockdale was born in 1883; after graduating at Cambridge, he was appointed in 1905 mycologist and lecturer in agricultural science in the Imperial Department of Agriculture for the West Indies, the prototype of the majority of Colonial departments of agriculture, which was later merged in the Imperial College of Tropical Agriculture. His administrative ability early attracted attention and in 1909 he became assistant director of the newly organised Department of Agriculture in British Guiana. In 1912 he was promoted to be director of agriculture in Mauritius, and entrusted with the duty of organising the new Department established on the recommendation of the Royal Commission of 1909. So well did he perform this task that his successors were able to build with security on the foundations which he laid; this was no mean accomplishment in those days, when the importance of departments of agriculture was not invariably recognized and the most suitable form for their activities was not always clear.

In 1916 Stockdale was transferred to the corresponding post in Ceylon where, up to that time, the Department of Agriculture had not entirely fulfilled expectations. During the next few years he successfully reorganised it and gave it the form which it has since retained; incidentally, the lines he evolved provided an administrative pattern for agricultural services which was followed afterwards in many other dependencies. He also played a leading part in the establishment of the rubber, tea and coconut research schemes of Ceylon, which were the forerunners of many other crop research institutes later established elsewhere in the Colonial dependencies. The fine block of administrative offices and laboratories at Peradenyia in which the Department of Agriculture is housed were erected during his tenure of office and are a lasting monument to his activities.

In 1929 he accepted appointment as agricultural adviser to the Secretary of State for the Colonies, a post created on the recommendation of the Lovatt Committee on the staffing of Colonial departments of agriculture, which he occupied for the next eleven years. During this period he played a leading part in the organisation and development of the Colonial Agricultural Service and of the Colonial Advisory Council on Agriculture and Animal Health, of which he was the first vice-chairman. He also made numerous visits and tours to the majority of the Colonial dependencies, incidentally visiting a number of other countries. The results of these tours were summarized in a series of reports which were models of clarity of exposition, and contained suggestions, observations and recommendations which often formed the basis of future policy and developments.

Stockdale's outstanding ability and profound knowledge of Colonial conditions caused him to be selected in 1940 for the difficult and responsible post of comptroller for development and welfare in the West Indies, constituted on the recommendation of the West India Royal Commission of 1938–39. As such he was charged with the apportionment and general administration of the grants for development and improvement of the West Indian Colonies amounting to £1,000,000 per annum under the first Colonial Development and Welfare Act. He was assisted by a team of experts in agriculture, public health, education, economics and other branches of social service, which eventually became affectionately known as the 'Stockdale circus'. The post was one of more than ordinary difficulty, particularly so having regard to the diversity of aspects concerned and the oft-times conflicting interests involved, and he discharged the duties with marked ability and considerable success.

In 1945 he returned to England to assume the post of adviser for development and welfare at the Colonial Office, in which capacity he was concerned with the examination, criticism and revision of the numerous schemes submitted by Colonial Governments and others for developments under the Colonial Development and Welfare Acts, a task for which he was pre-eminently fitted in virtue of his past experience.

When the Colonial Development Corporation was inaugurated in 1948, he was the obvious choice for the post of vice-chairman. About the same time he accepted office as chairman of the governing body of the Imperial College of Tropical Agriculture, of which he had been a member for a number of years, in succession to Sir Eric Macfadyen.

Stockdale's achievements were many and covered a vast field; but it is probably in connexion with agriculture, and more particularly agriculture in its Colonial and tropical aspects, that he will be specially remembered. His knowledge in this latter regard was profound and extensive; gifted with a clear and retentive memory and a faculty for grasping essentials, he could invariably be relied upon for a sound and authoritative pronouncement on almost any topic relating to Colonial agriculture that came up for notice. He was a remarkably sound judge of character, a faculty which was invaluable in the selection of candidates for entrance to the Colonial Agricultural Service. It is certainly not too much to say that this Service owes more to him than to any other individual.

His work was for the most part on the administrative rather than on the scientific side; but that he possessed capacity for research of no mean order is shown by his early scientific work, and particularly by a paper published in 1907 in which he described a technique for producing sugar cane seedlings of which both male and female parents were known; this was the forerunner of the later work of Jeswiet in Java and Barber in India which completely revolutionized cane breeding. There is little doubt that had Stockdale not forsaken research for administration, he would in due course have gone far as a research worker.

With his great qualities as an administrator he combined tact, an unfailing sense of humour, and serene imperturbability in the most difficult circumstances. His demeanour was unassuming and he was always approachable. By those who, like the writer, were privileged to work in close association with him for a space, he will be remembered not only as an able administrator with an untiring capacity for work, but also as a friend upon whose kindness, sympathy and tact one could always rely.

He married in 1908 Miss Annie Dora Packer, by whom he had two sons and to whom he was devoted. She was his constant companion, and her death last

year was a heavy blow which it may be surmised hastened his end. His death leaves a gap which cannot easily be filled, while his many achievements will continue to bear fruit for years to come.

H. TEMPANY

IN my recollection Sir Frank will remain always as a man possessing the qualities of sympathy, patience and understanding in rare degree. To the Colonial Development Corporation he was many things besides. His good name in the Colonies was a great asset. Doors opened to him readily. Of knowledge on Colonial agriculture, horticulture and topography he was an encyclopædia. Whenever new schemes were under consideration his mind rapidly surveyed the initial, often daunting, obstacles of preliminary experiment and investigation. If a new crop were mooted, on new ground, his advice as a starting point was often something like this: "Yes, it should be all right if the rainfall is not higher than 70 in.; but if, as I suspect, it is 100 in. or more, the crop will suffer from such-and-such disease." There was no consciousness of superior merit in his voice as he imparted his quiet advice, the distilled essence of his own knowledge and life's experience. As an agricultural expert alone, his value to the Corporation was beyond compute; but he was not content to limit his duties even to this broad sphere. As deputy chairman he played a routine part in nearly every scheme which was undertaken. More than that, he served as chairman of the Corporation's subsidiary in East Africa, and the effort of travel in that region in no way discouraged him from fulfilling his obligations there. To the end he remained eager for work—and it is by his work that he will still be remembered long after those who knew him as a sterling colleague and a kind friend have themselves passed away.

TREFGARNE

Mr. E. E. Green

MR. E. E. GREEN, who died at Camberley on July 2, was well known as an authority on the Coccidæ and as Government entomologist in Ceylon. No 'expert' employed by the Ceylon Government was so well known to the planting community as 'Pouchee Green' as he was called; 'pouchee' is the Tamil word for an insect. Green, who was born in Ceylon in 1861, was not trained as an entomologist. His father, Mr. John Philip Green, of Colombo, sent him to Charterhouse for his education. Returning to Ceylon in 1880, he became a tea planter. In 1886 the coffee industry in Ceylon was threatened by the green scale bug, a pest which seemed likely to put an end to the industry. Green, who had an inborn love for natural history, turned his attention to this pest and published a paper on the species, which was printed by the Government of Ceylon.

The Planters' Association was impressed by Green's work, and he was invited to visit estates and advise on methods of dealing with pests, and a few years later, in 1897, Green was appointed Government entomologist. The post was at first honorary, but later he became economic entomologist at the Peradeniya Botanic Gardens. This was his most active period. Being a man with private means, he was able to take leave in England at his own expense, when his studies made this necessary. In 1913 the Ceylon Government placed the scientific officers at Peradeniya under a new department, the Agricultural Department. Green, who was then fifty and suffering from malaria, retired at this time.

In England, Green settled at Camberley and devoted his time to his favourite group, the Coccidæ. In these he became an international authority and spent much of his time naming collections from all over the world for his numerous correspondents. All this work was done at his own expense, often for Government departments. While intolerant of most professional entomologists, he was extremely helpful and generous to these correspondents. The coloured plates of his great work, the "Coccidæ of Ceylon", were drawn by himself. The book was issued in five parts over a period of twenty-six years and remains his chief monument. His interest in entomology was general and he wrote more than four hundred papers. In 1923 the Royal Entomological Society honoured Green by making him president. He leaves a widow, two sons and a daughter.

Prof. A. Lo Surdo

ITALIAN geophysics lost one of its most notable leaders on June 7 with the death, at the age of sixty-nine, of Prof. Antonino Lo Surdo, founder and director of the National Institute of Geophysics at Rome. Born in Syracuse, he graduated in physics at Messina. The great Messina earthquake of 1908 robbed him of all his family, save a brother, a loss that cast a shadow of sadness over his whole later life, in which he contracted no further family ties. He taught and carried out research at Messina and, from 1919, at the University of Rome, where he held the chair of physics until his death; he gave great attention to experimental demonstrations in his teaching.

By very delicate measurements Lo Surdo disproved Landolt's theory that chemical reactions were accompanied by an appreciable variation of mass; and among other spectroscopic studies, he independently, and at about the same time as Stark, discovered that electric fields affect the spectra of gases emitting radiation. He also worked on interference and other properties of microwaves, on binaural hearing and acoustic physiological properties of the human ear, and on thermionics.

In later life Lo Surdo devoted himself increasingly to geophysics, in many branches. When the Italian National Research Council was initiated at the end of the First World War, he secured the foundation under its auspices of the National Institute of Geophysics, which later became an independent body; it has supported many geophysical stations and projects in Italy, and in particular has greatly developed the Rome seismological station. Very recently he founded the beautifully produced *Annali di Geofisica*. He was present at last year's assembly of the International Union of Geodesy and Geophysics at Oslo, and those who met him there will grieve to learn of his death.

WE regret to announce the following deaths:

Dr. G. S. Baker, O.B.E., the first superintendent of the William Froude Laboratory, National Physical Laboratory, on August 16, aged seventy-one.

Prof. A. Boivin, director of the bacteriological laboratory of the National Centre of Scientific Research, Strasbourg, on July 10.

Mr. H. O. Newboult, fellow and mathematical tutor of Merton College, Oxford, aged fifty-two.

NEWS and VIEWS

Physiology at King's College, Newcastle: Prof. D. Burns

At the end of the present academic year, Prof. David Burns retires from the chair of physiology in the Medical School at King's College, Newcastle upon Tyne. In 1921, when Burns succeeded Menzies, the Department of Physiology was small but with a long and honourable record. It was founded, with a lecturer in charge, in 1832 by a group of physicians and surgeons in Newcastle, and was the first department of physiology in England to be so designated. Sir Thomas Oliver was appointed first university professor of physiology in 1887. He was succeeded by Bainbridge in 1911. Burns inherited a department with only two assistants and the 'bulge' of students following the First World War. He leaves a large department, sumptuously housed, in the largest provincial medical school in England. Such changes take toll of the time and energies of academic staff. There was, too, a period of intense distraction in the 'thirties when the relationship of the Newcastle Medical School, and of Armstrong College, to the University of Durham came under close scrutiny. These periods of *Sturm und Drang* militated undoubtedly against intense prosecution of research. Burns early realized that teaching would have to take precedence. Yet the list of publications from his Department during these twenty-eight years is by no means unimpressive. In his later years, he became actively interested in the problems of physical fitness, a natural focusing of his life-long interest in social conditions and in youth movements, especially the Boy Scouts. In 1943, Newcastle honoured him by making him a justice of the peace. In this office Burns found once again an outlet for his interest in social welfare. It can truthfully be said that Burns is handing over to his successor a department in good heart, a solid foundation for a flourishing school of physiology.

Prof. A. A. Harper

Dr. A. A. Harper, who has been appointed to succeed Prof. D. Burns, is a graduate of the University of Aberdeen, where he first read for a degree in classics. After qualifying in medicine he filled the usual clinical appointments and then took up physiology, working first with the late Prof. McSwiney in Leeds and afterwards at St. Thomas's Hospital. Prof. Harper's interests are in the control of digestive secretion, and his work on secretin led in 1943 to the discovery with H. S. Raper of pancreozymin. By this time Harper had taken up an appointment as lecturer in human physiology in the University of Manchester and later he became reader there. At present he is studying the further purification of pancreozymin and also working on the control of gastric secretion. Prof. Harper is a most successful teacher, and his students and colleagues have not been slow to recognize this. The happy combination of teaching and research capabilities make it certain that he will be a stimulating influence in the Medical School at Newcastle.

Science Service: The Popular Exposition of Science

Mr. Watson Davis, the director of Science Service in Washington, has recently explained the origin of his organisation and how it is working to-day in the United States. In 1919, E. W. Scripps, the founder of the famous group of newspapers that bears his name, began to believe that democracy would not develop unless it adopted a scientific approach to its problems. Two years later, in collaboration with Dr. W. E. Ritter, a biologist of the University of California, he founded Science Service, with trustees nominated by three scientific groups, the National Academy of Sciences, the National Research Council, the American Association for the Advancement of Science, and two newspaper groups, the E. W. Scripps Estate and the journalistic profession.

Science Service was given a double task. It had to convince the American newspapers that science is news and then it had to distribute and sell the popular science material it produced. To-day its news service supplies more than two hundred newspapers and other publications, with a readership of about ten million people, while for eighteen years it has been broadcasting a weekly programme called "Adventures in Science" over the Columbia Broadcasting System. Its weekly magazine, *Science News Letter*, has a circulation of more than fifty thousand, and a monthly magazine, *Chemistry*, is also widely circulated. Another service to its members is called "Things of Science". Under this scheme each month ten thousand members of Science Service receive little boxes containing a number of specimens, a booklet of explanations, museum legend cards and directions for a number of experiments.

Science Service also acts as sponsor to the movement known as Science Clubs of America, to which many of the science clubs in secondary schools are affiliated; these are able to obtain materials free of charge from Science Service. Other ways in which Science Service helps in the popularization of science is by aiding research and distributing the results, by making its news services available to foreign countries and by helping Unesco. Full particulars of Science Service may be obtained from 1719 N. Street, N.W., Washington, D.C.

Commonwealth and United Kingdom Universities Interchange Scheme

The British Council has introduced a scheme under which travel grants are awarded to facilitate interchange of university teachers and scholars between the Commonwealth countries and the United Kingdom. Thirty-nine such awards have been made for the current year. The scheme has been established as the result of discussions which took place at the first post-war congress of universities of the Commonwealth, held last year at Oxford. The grants, which may be made to assist travel to or from the United Kingdom and Commonwealth countries, are awarded for two purposes. Grants are made to university teachers on study leave and to postgraduate research workers, holding research grants, who intend to work for at least six months in another university. Priority is given to the first of these categories. Grants are also made to enable distinguished scholars and scientific men to accept invitations for short visits to other universities. The scheme is administered by the British Council in collaboration with the Association of Universities of the British Commonwealth. The first awards were made in March this year to enable Lord Eustace Percy, Sir Raymond Priestley and Prof. J. Dover Wilson to take part in the celebrations which marked the granting of a charter to the University of Natal. The awards for the year include grants to four other distinguished scholars from the United Kingdom, three of whom will go to Canada and

one to Australia in September and October this year. Awards have also been made to thirty-two university teachers and postgraduate research workers as follow: Australia, 11; India, 2; New Zealand, 7; Pakistan, 3; South Africa, 6; United Kingdom, 3.

Industrial Output of the U.S.S.R.

HIGHLY compressed, a paper of twenty-seven pages is nevertheless the only comprehensive statement available to the student of industrial output within the Soviet Union during and since the Second World War ("Industrial Development in the U.S.S.R.", Bull. 1 (May 1949). Bulletins on Soviet Economic Development, Faculty of Commerce and Social Science, University of Birmingham). It has become obvious that until similar schools of economic inquiry mature the authority of the Department of Economics and Institutions of the U.S.S.R. under Dr. A. Baykov remains unchallenged in its field. Hitherto, Soviet statistics of economic output have been considered unreliable; but the standing of Dr. Baykov as interpreter, inevitably enhanced by the high quality of this Bulletin, now provides a standard to which we may confidently appeal.

The summary of the industrial destruction wrought by the Germans is a terrible document, perhaps incomprehensible to those inexperienced in total war. In five months after invasion at least three-fifths of the putput of coal, iron ore and steel was, in each case, lost to the U.S.S.R., though according to Dr. Baykov's calculation more than twenty-four million Russians were saved by evacuation from the very territories which formerly produced these major contributions of economic wealth. Less than one year after the invasion of European Russia the Asiatic region had attained an output in their war industries equalling the total output of these industries in 1940 for the entire Soviet Union. The Bulletin is to a large extent a close examination of the rapidly growing contribution of the Eastern lands. Much of the argument is unfortunately unintelligible without carefully selected maps, and the aid of a cartographer is demanded.

Pest Infestation Research

DURING the period from 1927 until the outbreak of the Second World War, Prof. J. W. Munro devoted a great part of his energies to building up in the Imperial College of Science and Technology an organisation for the scientific study and development of applied entomology in the special field of stored products. The Empire Marketing Board supported this enterprise, and so did sections of the trade which handled such products as dried fruit, tobacco and cacao. A great deal of valuable work was done; but the main section of the industry, that dealing with cereals, was not interested. Only in 1938 were industrial interests sufficiently concerned to approach the Department of Scientific and Industrial Research and to share the cost of a survey to discover as much as possible about the facts of infestation in Great Britain. The results of this survey were such as to result in 1940 in the establishment of a Pest Infestation Research Laboratory by the Department of Scientific and Industrial Research, which took over in large part Prof. Munro's premises and staff at Slough. Rapid expansion followed during the War and post-War years. The history and achievements of the laboratory have now been set out in a pamphlet entitled "Pest Infestation Research 1947" (London: H.M. Stationery Office, 6*d*. net). This is in effect the first report from the Pest Infestation Laboratory. It gives a most interesting account of the research that is being carried out on the biology of the pests of stored products, notably on the use of carbon dioxide production as a measure of infestation in grain, on the application of fumigants to stored products in barges and warehouses and silo bins, on the use of insecticidal dusts and sprays under warehouse conditions, on the protective impregnation of sacks with insecticides, on the development of spraying equipment and many other matters. It is evident that the Department of Scientific and Industrial Research is pursuing an enlightened policy of carrying out research at all levels, from the fundamental to the applied, in its own laboratory.

County College Problems

IN an address to the 1949 annual general meeting of the British Psychological Society, Sir Philip Morris attempted to forecast some of the problems which will have to be considered when county colleges are established. His remarks have now been published in a recent issue of *Occupational Psychology* (23, No. 3; July 1949). Sir Philip believes that there will be an insufficient understanding of the main aim and purpose of county colleges among all people concerned with them, particularly among the young people themselves, the employers who have so much influence over them and the parents. Another main problem is that county colleges will have only partial and in some respects ill-defined aims on which to base their initial plans. For the young people themselves the degree of influence of the county college will comparatively be very much smaller than the degree of influence of any form of compulsory schooling now known. The employer's attitude to county colleges will be governed by the fact that in many cases boys and girls are being employed between the ages of fourteen and eighteen years in ways which do not necessarily bear any obvious relationship to their adult employment. The novel features of a large turnover of students in relation to accommodation at the county colleges as well as an extremely short 'exposure' of boys and girls to the influences of formal education may lead to a squeezing out of the curriculum of those activities which are more time-consuming than others—for example, practical work as opposed to arithmetic. The challenge of these problems may have the effect of giving a new turn to the attitude to education in Great Britain.

Work and Leisure

IN an interesting article (*J. Inst. Personnel Management*, 31, No. 304; July–August 1949), Mr. Guy Hunter discusses the subjects of apathy, energy and the use of leisure. Among the subjects considered are whether the leisure of a manual labourer differs from that of a filing clerk because a different kind of energy is left over from the job, and whether there is a correlation between the interest and excitement, or boredom and half-activity, of the day's work with the subsequent use of leisure? Hunter tentatively suggests that if all the powers of human beings are denied expression in the day's work, the result is a feeling of disgruntlement which, in common experience, makes it harder to start any creative activity. Conversely, the more these powers are used, the more the enjoyment of that use will lead on to further activity. The energetic thus become more and more energetic, and the dissipators become more

and more dissatisfied. These observations are put forward with little to substantiate them experimentally, and the author pleads for a competent analysis of the relationship between work and leisure. If the theory that there is a vicious and a virtuous circle in the use of energy be true, a different attitude in industry may have to be developed, and particularly towards the young worker.

Royal Photographic Society's Annual Exhibition

THE Royal Photographic Society's ninety-fourth annual exhibition of photography will be opened in the Society's House at 16 Princes Gate, London, S.W.7, on September 8. For this year's exhibition, 5,300 entries were received, of which 863 have been accepted. Limitations of space in the Society's House make it necessary to divide the exhibition into the following two parts: Part 1: pictorial, colour and stereoscopic (prints and transparencies), September 9 to October 2, inclusive; Part 2: scientific, Nature, record and technical (prints and transparencies), October 8 to 26, inclusive.

Institute of Metals: Autumn Meeting in Paris

BY invitation of the Société Française de Métallurgie and the French Non-Ferrous Metal Industries, the Autumn Meeting of the Institute of Metals will be held this year in Paris during October 3–8, followed by tours outside the Paris area. At the same time, and in the same building, the annual meeting of the Société Française de Métallurgie will be held. Care will be taken that the non-ferrous sessions of the two societies do not clash. The meeting of the Société Française de Métallurgie will open at 10 a.m. on October 3, when Dr. R. Seligman will deliver an address in French. Members of the Institute of Metals are invited to be present. This is the first meeting of the Institute to be held outside the British Isles since 1936.

The programme includes the twenty-seventh Autumn Lecture, to be delivered by Prof. Georges Chaudron, on "Recent French Work in the Field of Light Alloys". The works, etc., to be visited include the laboratories of the Centre Nationale de la Recherche Scientifique, Vitry; Le Magnésium Industriel, Levallois; Manufacture d'Armes de Paris (MAP), St. Denis; Laboratoires du Centre National de la Recherche Scientifique, Bellevue; Cie. Facel-Metallon, Colombes; the Michelin Train; Centre Technique de l'Aluminium, Paris; Régie Nationale des Usines Renault, Billancourt; Etablissements JAPY, Arcueil; Société des Trèfileries et Laminoirs du Hâvre, Cableries de Saint-Maurice; and Fonderies Montupet, Creil.

Symposium on Electronics

THE Electronics Section of the Scientific Instrument Manufacturers' Association is arranging a symposium to be held at the Examination Hall, Queen's Square, London, W.C.1, during November 2–4. A separate hall has been secured in the building so that a comprehensive display of the latest types of British scientific and electronic instruments can be demonstrated during the period of the symposium. The topics for discussion include electronic instrumentation in atomic research, electronic amplifiers, magnetic amplifiers, recent improvements in electronic measuring techniques, measurement of transient phenomena, an industrial electronic servo-mechanism, and co-operative research at the British Scientific Instrument Research Association. Entrance to the symposium itself will be by ticket (covering also the exhibition), obtainable on application to the Secretary, Scientific Instrument Manufacturers Association, 17 Princes Gate, London, S.W.7.

Symposium on Metallurgical Applications of the Electron Microscope

THE Institute of Metals is organising an all-day Symposium on "Metallurgical Applications of the Electron Microscope", which will be held at the Royal Institution, London, S.W.1, on November 16, commencing at 10 a.m. The following societies are associated with the Institute in arranging this meeting: Chemical Society; Faraday Society; Electron Microscope Group of the Institute of Physics; Institution of Electrical Engineers; Iron and Steel Institute; Physical Society; and Royal Microscopical Society.

Aslib Guides

ASLIB is issuing a series of "Guides" intended to form cumulatively a new edition of the Aslib Directory. No. 3, entitled "Beverages and Foods" (Aslib. Pp. iii+56. 12*s*. 6*d*. net. 10*s*. to members), is in three sections. The first deals with libraries and loan services and with the Department of Scientific and Industrial Research. The second details the organisations in Great Britain which are the main sources of information on beverages and food, omitting references to commercial firms. The third section lists publications in three classes: periodicals printing abstracts or lists of references; directories, annuals and yearbooks; and periodicals in general. Separate subject indexes to the first two and to the third section are provided, and the Guide is printed in a form suitable for inclusion in a loose-leaf binder.

Announcements

THE first Douglas Lea Memorial Lecture of the Hospital Physicists' Association will be given, on September 16, at the British Institute of Radiology, 32 Welbeck Street, London, W.1, when Dr. F. G. Spear, of Cambridge, will speak on "The Physicist and his Colleagues".

UNESCO proposes to publish later in the year a "Manual on the International Exchange of Publications". It is intended to publish as an annex to this Manual a classified list of institutions, including libraries, universities, scientific institutions, learned societies, etc., throughout the world, which are willing to exchange either their own publications or other publications which they have regularly at their disposal. Further information can be obtained from Unesco Clearing House for Publications, 19 Avenue Kléber, Paris, 16e.

MESSRS. H. J. ELLIOTT, LTD., Treforest Trading Estate, Glam., have submitted a specimen of their 'E-MIL' "Companion" pocket thermometer, 7*s*. 6*d*. This thermometer is graduated from 35° to 220° F. by 2° marks, and is fixed at one end to a bracket sliding in a slot in a neat plastic case some 5 in. long. The case has a convenient metal pocket-clip.

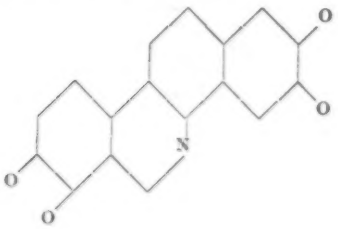
ERRATUM. Dr. Forrest Fulton states that, in his communication entitled "Growth-Cycle of Influenza Virus", in *Nature* of July 30, p. 189, the figure 5120 which appears three times in the third column of Table 1 should be, on each occasion, 512.

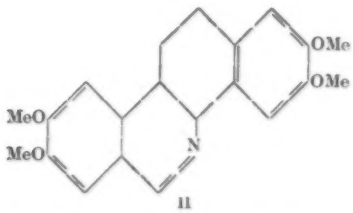
LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications

Synthesis of a Substance Containing the Chelerythrine–Sanguinarine Skeleton (C, N, O)

THE skeleton indicated is (I) and we first attempted an extension of the method whereby (II) had been synthesized in 1937 [1].

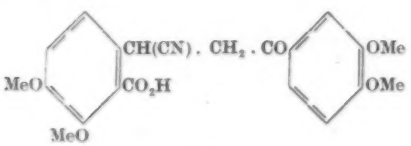




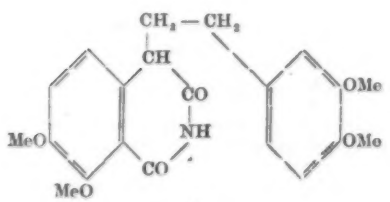
II

However, cyclization of 1-formamido-6 : 7-dimethoxy-2-(2′-bromo-4′ : 5′-dimethoxy)phenyl-1 : 2 : 3 : 4-tetrahydronaphthalene could not be effected. R. D. Haworth[2] was also interested in this problem and prepared 6 : 7-dimethoxy-3-(3′ : 4′-dimethoxy)phenacylphthalide (III), but was unable to add the elements of hydrocyanic acid to this substance.

In ignorance of Haworth's work, for the first months, we adopted the same route and were fortunate to find appropriate conditions for the reaction of III with potassium cyanide. The product (IV), m.p. 148–152° (found: C, 63·2; H, 5·5 per cent), gives, on heating, a neutral, yellow compound, m.p. 234–35° (found: C, 65·8; H, 5·0; N, 3·2 per cent), and a molecule of water.



IV



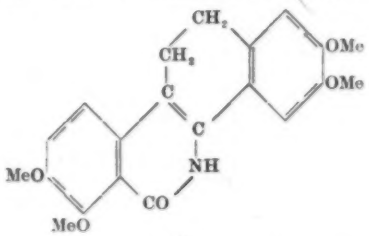
V

Hydrolysis of this yellow compound by means of boiling 2*N* sodium hydroxide, or of the nitrile-acid (IV) by means of hydrogen peroxide followed by 2*N* sodium hydroxide, afforded the keto-dibasic acid related to IV; m.p. 195–97° (decomp.) (found: C, 60·1; H, 5·3 per cent; equiv. by titration, 218).

Potentiometric titration showed two carboxyl groups to be present, and the anhydride had m.p. 164–66° (found: C, 63·1; H, 4·9 per cent) and the properties of a homophthalic anhydride.

Reduction of the keto-dibasic acid (IV, CN → CO_2H) by Clemmensen's method gave a dibasic acid (CO → CH_2), $C_{21}H_{24}O_8$, m.p. 171–72° (decomp.) (found: C, 62·4; 62·6; H, 6·0, 5·8 per cent; *M*, 417) (two carboxyls by potentiometric titration and anhydride, m.p. 155–56°).

On heating the ammonium salt, the imide (V), namely, 4-[β-(3′ : 4′-dimethoxyphenyl)ethyl]-7 : 8-dimethoxyhomophthalimide, was obtained; m.p. 127–127·5° (found: C, 65·7; H, 6·1; N, 3·3 per cent). On cyclization by means of phosphoric anhydride in glacial phosphoric acid solution, 7 : 8 : 4′ : 5′-tetramethoxy-3 : 4-dihydro-1 : 2-benzphenanthridone (VI), m.p. 259–61° (found: C, 68·4, 68·8; H, 5·8, 5·8; N, 3·8 per cent) was obtained in good yield.



VI

The further steps necessary to develop this method so as to effect the syntheses of chelerythrine and sanguinarine, also of their dihydro derivatives, are obvious, and unlikely to cause serious difficulty. Experiments on the synthesis of chelidonine and α-homochelidonine are also in progress.

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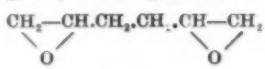
June 27.

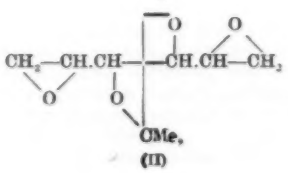
[1] Richardson, Robinson and Seijo, *J. Chem. Soc.*, 835 (1937).
[2] Haworth, R. D., *J. Chem. Soc.*, 1312 (1937).

Formation of a Tetrahydrofuran Derivative from Diallyl

WHEN diallyl (hexa-1 : 5-diene) is treated with perbenzoic acid, 1 : 2–5 : 6-diepoxyhexane (I) is produced in good yield (80 per cent).



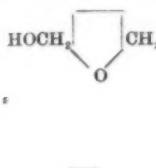
I



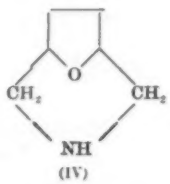
(II)

Evidence that (I) does represent the structure of this compound is adduced from the method of preparation and from the fact that the epoxide rings are very labile to hydrolytic agents (for example, water, hydrochloric acid, sodium methoxide and ammonia), a behaviour which is paralleled by that of an analogous compound in the hexitol series, namely, 1 : 2-5 : 6-dianhydro-3 : 4-*iso*propylidene-mannitol[1] (II).

When (I) was boiled with water, scission of the epoxide rings was effected. It was expected that 1 : 2-5 : 6-tetrahydroxyhexane would be formed. Such a reaction did, indeed, occur when 1 : 2-5 : 6-dianhydro-3 : 4-*iso*propylidene mannitol (II) was similarly treated because, in this case, 3 : 4-*iso*propylidene mannitol resulted. The hydrolysis product of (I) was not, however, 1 : 2-5 : 6-tetrahydroxyhexane, but 2 : 5-*bis*hydroxymethyltetrahydrofuran (III), which was obtained in 65 per cent yield.



(III)



(IV)

The proof of constitution of this product was achieved in the following way. The fact that it was not the expected tetrahydroxyhexane was concluded from the results of lead tetra-acetate oxidation, which gave no evidence of vicinal hydroxyl groups. It formed a liquid diacetyl derivative and a crystalline di-toluene-*p*-sulphonyl derivative. The latter compound showed m.p. 114–118°, four recrystallizations from ethyl alcohol failing to produce a sharper melting point. Treatment with sodium iodide in acetone showed that both toluene-*p*-sulphonyl residues were attached to primary hydroxyl groups. Newth and Wiggins[2] previously obtained 2 : 5-*bis*hydroxymethyltetrahydrofuran by the hydrogenation of 5-hydroxymethylfurfural, and the physical properties recorded for this product are in agreement with those observed for the dihydroxy-compound derived from diallyl. The same authors prepared 2 : 5-*bis*-hydroxymethyltetrahydrofuran di-toluene-*p*-sulphonate, m.p. 127·5–128°, and in admixture with the di-toluene-*p*-sulphonyl derivative obtained via diallyl, no depression of the melting point of the latter toluenesulphonate was noted (118–124°). It would appear that the di-toluene-*p*-sulphonate of m.p. 114–118° is a mixture of the two theoretically possible geometrical isomerides, whereas that of m.p. 127·5–128° is a single substance. An X-ray powder photograph of the two substances failed to show any difference between them.

Conclusive evidence that the di-toluene-*p*-sulphonate of m.p. 114–118° was indeed 2 : 5-*bis*hydroxymethyltetrahydrofuran ditoluene-*p*-sulphonate was obtained through its conversion, by treatment with methyl-alcoholic ammonia, into the imine (IV), 8-oxa-3-azabicyclo-(3 : 2 : 1)-octane, which was shown to be identical with that obtained by Newth and Wiggins (*loc. cit.*) from the di-toluene-*p*-sulphonate of m.p. 127·5–128°.

The formation of the imine (IV) demands the *cis* orientations of the two toluene-*p*-sulphonyloxy residues, and hence both the compound of m.p. 114–118° and that of m.p. 127·5–128° must contain this isomer, unless the conditions of their transformation into the imine (IV) are capable of effecting the conversion of the *trans*- to the *cis*-isomer.

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[1] Wiggins, L. F., *J. Chem. Soc.*, 384 (1946).
[2] Newth, F. H., and Wiggins, L. F., *J. Chem. Soc.*, 155 (1948).

Effect of Pressure on Velocity of Burning

In a recent paper Gaydon and Wolfhard[1] state: "In stationary pre-mixed flames of hydrocarbons at pressures between 1 atm. and a few mm. of mercury . . . the flame speed is independent of pressure". Reference is made to determinations by Wolfhard[2] of the effect of pressure on the burning velocities of acetylene/air, acetylene/oxygen and acetylene/oxygen/argon mixtures and also of butane/air mixtures. Some experiments of ours and various recorded measurements of the effect of pressure on burning velocity, excluding those in tubes, had led us to a different view.

Thus Ubbelohde and Koelliker[3], using the burner method, found for mixtures of air with methane, benzene, carbon monoxide, benzine vapour and 6 per cent acetylene a decrease of burning velocity as the pressure increased. For a 12 per cent acetylene/air mixture the burning velocity varied only slightly with pressure. Khitrin[4], and Kolodtsev and Khitrin[5], using the soap-bubble and the burner methods, found for mixtures of air and benzene, ether, and carbon monoxide that, as the pressure was increased, the burning velocity decreased. If the burning velocity is designated by V, and the pressure by P, they obtained a relation:

$$V = (k_1\sqrt{P} + k_2)/P,$$

where k_1 and k_2 are constants, and they also state that the results of Ubbelohde and his co-workers conform to this equation. The results quoted above were obtained for pressures above atmospheric; but there seems to be no reason for believing that a sudden change occurs at atmospheric pressure.

At reduced pressures Ubbelohde and Andwandter[6], using the burner method, found for carbon monoxide/air mixtures that the burning velocity showed a maximum at about 330 mm. of mercury, and dropped fairly rapidly each side of the maximum. Both Stevens[7] and Khitrin[4], using the soap-bubble method, found for carbon monoxide/oxygen mixtures that the burning velocity is independent of the pressure; but Fiock and Roeder[8] have pointed out that these workers were actually studying the effect of water vapour as well as pressure on the burning velocity, and hence that the results are of no value in estimating the variation of the burning velocity of such mixtures with pressure alone.

Garside, Forsyth and Townend[9] have used the burner method to find the effect of reduced pressures on the burning velocity of ethylene/air mixtures. Although their results are not tabulated, the graph shows that, over the majority of the burning velocity curve, there is a progressive increase in the burning velocity as the pressure is reduced. We have also investigated ethylene/air mixtures using an apparatus similar to Garside, Forsyth and Townend's, but computing the burning velocity in the manner described

Burning velocities of 7, 8 and 9 per cent ethylene/air mixtures in cm./sec. The values for pressures of 17 cm. of mercury are in brackets as their degree of accuracy is considerably less than the rest of the values.

Pressure (cm. of Hg)	7%	8%	9%
77	71	71	59
70	72	72	61
64·5	70	72	65
56	76	77	66
49	81	81	70
37	89	91	81
27	97	98	87
(17)	(109)	(108)	(103)

by Linnett and Sherratt[10]. The results for 7, 8 and 9 per cent mixtures are given in the accompanying table. Although the absolute values of the burning velocities given here may be as much as 5 per cent in error, their relative values are much more accurate, and the figures show that the burning velocity increases steadily as the pressure is reduced. Moreover, they are in quite good agreement with Tanford and Pease's prediction[11] that the burning velocity should vary inversely as the fourth root of the pressure. Although the agreement with their purely diffusion theory is so good, we do not believe that diffusion alone can account for all the intricacies of flame propagation, and it is significant that a purely thermal theory also leads to the expectation that the burning velocity should increase as the pressure decreases[12].

We are at present constructing an apparatus with which we hope to investigate more fully the effect of pressure on the burning velocity of explosive gas mixtures. However, an examination of the literature, together with our own limited experience, had led us to believe that most of the present evidence indicates that burning velocities are affected by pressure and that, for some hydrocarbons, as the pressure is lowered the burning velocity increases.

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P. J. Wheatley

Inorganic Chemistry Laboratory,
Oxford. March 8.

[1] Gaydon and Wolfhard, *Proc. Roy. Soc.*, A, **196**, 105 (1949).
[2] Wolfhard, *Z. tech. Phys.*, **24**, 206 (1943); results using acetylene as the combustible gas.
[3] Ubbelohde and Koelliker, *J. Gasbel.*, **59**, 49 (1916).
[4] Khitrin, *Tech. Phys. U.S.S.R.*, **3**, 926 (1936).
[5] Kolodtsev and Khitrin, *Tech. Phys. U.S.S.R.*, **3**, 1034 (1936).
[6] Ubbelohde and Andwandter, *J. Gasbel.*, **60**, 225 (1917).
[7] Stevens, Nat. Advisory Comm. Aeronaut. Reports, 372 (1931).
[8] Flock and Roeder, Nat. Advisory Comm. Aeronaut. Reports, 532 (1935).
[9] Garside, Forsyth and Townend, *J. Inst. Fuel*, **18**, 175 (1945).
[10] Linnett and Sherratt, *Trans. Farad. Soc.*, **44**, 596 (1948).
[11] Tanford and Pease, *J. Chem. Phys.*, **15**, 861 (1947).
[12] Jouguet, *C.R. Acad. Sci., Paris*, **168**, 820 (1919); **179**, 454 (1924). Daniell, *Proc. Roy. Soc.*, A, **126**, 393 (1930).

To determine the true dependence of flame velocity on pressure it is necessary to make a large number of measurements, because the velocity is not exactly constant within the stability region (see Wolfhard[1]). To make comparable measurements it is especially necessary to increase the burner diameter as the pressure is reduced, so that the diameter is inversely proportional to pressure. This was done for our measurements, but not for the older results referred to by Linnett and Wheatley. We do not deny that for the acetylene/air flame the flame velocity tends to increase slightly as the pressure is reduced; but at still lower pressure the velocity decreases again, and the effect is probably due to the nitrogen. For flames in which the nitrogen of the air is replaced by argon, we have not observed any measurable change of velocity with pressure. We would emphasize that our results, especially for oxy-acetylene flames, are based on a very large number of measurements with various burner diameters and cover a big range of pressure (from 1 atm. to less than 0·01 atm.).

The main purpose of our paper was to point out the relationship between the thickness of the luminous reaction zone and the distance which free atoms may diffuse against the gas stream. Our calculations of the dependence of velocity on pressure are only approximate, but appear to be a better approximation than the treatment of Tanford and Pease, which leads to the inverse fourth root law for the variation of velocity with pressure.

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[1] Wolfhard, H. G., *Z. tech. Phys.*, **9**, 206 (1943).

Photochemical Polymerization in Aqueous Solution

A new series of polymerization photo-sensitizers in aqueous solution, which is based on electron transfer excitation, is described for the first time. E. Rabinowitch[1] has interpreted the absorption spectra of some ion pairs such as $Fe^{3+}OH^-$, $Fe^{3+}Cl^-$, etc., as electron transfer spectra. The light absorption would, according to his hypothesis, cause the reduction of the metal ion and the oxidation of the anion to an atom or free radical; thus, for example, $Fe^{3+}OH^- \rightarrow Fe^{2+}OH$. No experimental evidence has been forthcoming which would demonstrate the presence of the latter in the irradiated solution. In this note we present such evidence, and this is based on the ability of these photochemically produced radicals or atoms to initiate the polymerization of vinyl compounds under conditions ($h\nu > 300$ mμ) in which no direct photopolymerization of the corresponding monomers would occur.

The general scheme may be illustrated with reference to $Fe^{3+}OH^-$:

1.	$Fe^{3+}OH^- \rightleftharpoons Fe^{2+}OH$	Excitation and primary dark back reaction.
2.	$Fe^{3+}OH \rightarrow Fe^{2+} + OH$	Separation of primary products.
3.	$Fe^{2+} + OH \rightarrow Fe^{3+} + OH^-$	Secondary dark back reaction.
4.	$Fe^{3+}OH + M \rightarrow HO—M— + Fe^{3+}$ (M represents a vinyl monomer) $OH + M \rightarrow HO—M—$	Initiation of polymerization.
5.	Possible recombination of OH radicals and subsequent reactions	

Baxendale, Evans *et al.*[2] have shown that OH radicals produced in the ferrous iron – hydrogen peroxide reaction may initiate polymerization in such compounds as acrylonitrile, methyl methacrylate, styrene, etc.

The same monomers were found to polymerize when solutions of $Fe^{3+}OH^-$ and monomer were irradiated with ultra-violet light of wave-length > 300 mμ. Monochromatic light of wave-length as high as 365 mμ was also found to lie within the effective range of wave-lengths. In the presence of monomers the rate of ferrous ion formation leads to quantum yields up to $\sim 10^{-2}$ (for 365 mμ) with saturated solutions (1·2 M) of acrylonitrile. It is because of the low

quantum yield that no oxygen evolution has been observed in previous work in the absence of monomers. The molecular weight average of the unfractionated methyl-methacrylate polymer has been determined by measurements of intrinsic viscosity of solutions of the polymer in benzene. Using the coefficients obtained by Baxendale, Bywater and Evans[3] to relate the intrinsic viscosity to the molecular weight, this was found to be 120,000, corresponding to a chain-length of 1,200. The photopolymerization in dilute ferric salt solution is practically suppressed in a strong acid medium (such as 3*N* perchloric acid) when the $Fe^{3+}OH^-$ equilibrium concentration becomes minimal.

Solutions of ferric iron ions in the presence of fluoride, chloride, oxalate and citrate ions under *p*H conditions in which the concentration of the ion-pair $Fe^{3+}OH^-$ is minimal show photo-reduction of ferric ion, and polymerization occurs. Spectrophotometric measurements indicate that an $Fe^{3+}F^-$ complex is present in aqueous solution, and we assume the active photo-sensitizers to be: $[Fe(OH)]^{++}$, $[FeCl]^{++}$ $[FeF]^{++}$, $[FeC_2O_4]^+$ and $[FeHCitr]^+$. The formula of the latter complex has only recently been established by spectrophotometric measurements[4]. In both the latter cases, where the anion of the complex is divalent, it would appear that a radical ion with a negative charge does account for the initiation of polymerization. The presence of the $C_2O_4^-$ radical ion in aqueous solution has been suggested by Weiss[5], who considered that it would account for those phenomena attributed to 'active oxalic acid'.

It is interesting to note that $[FeBr]^{++}$ and $[FeSCN]^{++}$ were found inactive as photo-sensitizers for long-chain polymerization, although ferric ion was reduced and unsaturated monomer disappeared during the irradiation. This would be in agreement with other experiments carried out by Baxendale, Evans and Cowling[6], which also indicate that bromine atoms add on to the C=C bond so as to form simple addition products or polymers of very low chain-length.

Methyl methacrylate polymer, formed when the $Fe^{3+}Cl^-$ ion-pair was the photosensitizer, gave a molecular weight average of 20,000. A micro-analytical determination of the chlorine in the polymer is in good agreement with the viscometric molecular weight determination, if it is assumed that the polymer contains one chlorine atom at each end.

It is noteworthy that the electron transfer excitation requires a larger energy than that corresponding to the reaction $Fe^{3+} + OH^- \rightarrow Fe^{2+} + OH^+ \sim 40$ kcal. in aqueous solution[7]. This is due to the fact that the primary transition does not occur between the two dissociated and fully solvated states, but rather between the $Fe^{3+}OH^-$ ion-pair and the $Fe^{2+}OH$ at such a configuration in which the repulsion energy of compression is considerable.

Apart from the ferric ion systems, $Ce^{4+}OH^-$ and $Pb^{3+}Cl^-$ have been proved to be active photosensitizers in the polymerization of vinyl compounds, in agreement with their characteristic electron transfer spectra.

The biological importance of these problems with regard to the mechanism of photosynthesis has been pointed out by R. Hill and R. Scarisbrick[8], who found that chloroplasts *in vitro* have photocatalytic activity for the photo-oxidation of water by ferric salts.

Detailed accounts of the quantitative studies of the mechanism of reaction will be published shortly.

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N. Uri

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Manchester 13.
Feb. 23.

[1] Rabinowitch, *Rev. Mod. Phys.*, **14**, 112 (1942).
[2] Baxendale, Evans and Park, *Trans. Farad. Soc.*, **42**, 155 (1946). Baxendale, Evans and Kilham, *Trans. Farad. Soc.*, **42**, 668 (1946).
[3] Baxendale, Bywater and Evans, *J. Polymer Sci.*, **1**, 237 (1946).
[4] Lanford and Quinan, *J. Amer. Chem. Soc.*, **70**, 2900 (1948).
[5] Weiss, Dis. Farad. Soc., No. 2, 188 (1947).
[6] Baxendale, Evans and Cowling (unpublished results), and Cowling, Ph.D. thesis, Leeds (1949).
[7] Evans and Uri, *Trans. Farad. Soc.*, **45**, 224 (1949).
[8] Hill and Scarisbrick, *Proc. Roy. Soc.*, B, **129**, 238 (1940).

Decay of Palladium-109

Slow neutron bombardment of palladium gives rise, among others, to a 13-hour activity which according to Rall[1] belongs to palladium-109. This isotope is a β-emitter, and the spectrum has an upper limit of 1·0–1·1 MeV. (cloud chamber, abs.)[2]. No γ-radiation could be observed to accompany the decay[3].

We have recently investigated this isotope with the spectrometer technique (see Fig. 1). The sample consisted of a 14·6 mgm./cm.² palladium sheet. A Fermi plot of the spectrum shows that this consists of only one component with an upper limit of 0·95 MeV. Furthermore, there are two strongly converted β-lines, corresponding to the *K*- and *L*-lines of a γ-ray of 87 keV. energy. After correction has been applied for absorption in the sample itself, a com-

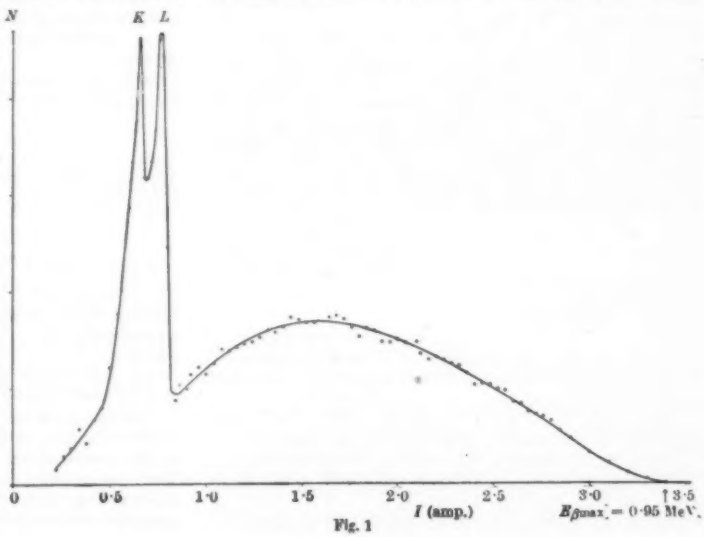

Fig. 1

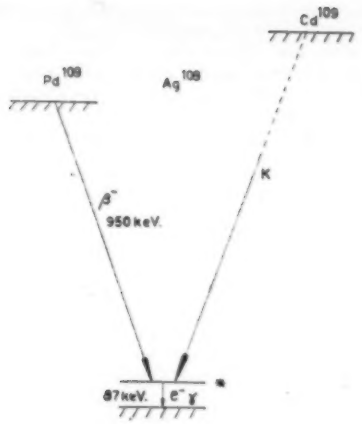

Fig. 2

parison between the intensities of the two lines and the continuous spectrum gives a total internal conversion coefficient of about 92 per cent. This figure must be regarded as an estimate, due to the sample being thick.

An absorption measurement of the primary soft γ-radiation and the strong X-radiation (22 keV.) shows that the internal conversion coefficient probably is higher than 92 per cent.

After correction, the ratio of the intensities of the two internal conversion lines N_K/N_{L+M} is found to be 1·3. From this value a calculation of the multipole order l for electric radiation based on the curves of Hebb and Nelson[4] leaves the two possibilities $l=3$ or $l=4$ open.

It is known that cadmium-109 decaying by K-capture leads to a metastable level in silver-109 with the excitation energy 87 keV. [5,6]. This is the same energy as found in our case, and it seems, therefore, almost certain that the disintegration of palladium-109 and cadmium-109 forms another example where two different nuclei decaying to the same nucleus have an excited level in common, which in this case is metastable (see Fig. 2).

If the formula by Sēgré and Helmholz[7] is used to compute the half-life of the metastable state, it is found that τ is 0·01 sec. for $l = 3$ and 10^5 sec. for $l = 4$. The computed half-lives have been corrected for disintegration by internal conversion electrons according to Hebb and Uhlenbeck[8], on the assumption that this coefficient is 92 per cent. Silver-109 is known to have a half-life of 40 sec., that is, between the theoretical values for $l = 3$ and $l = 4$.

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[1] Rall, W., *Phys. Rev.*, **70**, 112 (1946).
[2] Seaborg, G. T., and Perlman, I., Table of Isotopes, *Rev. Mod. Phys.*, **20**, 585 (1948).
[3] Seiler, J., reported in Plutonium Project Report CC-2310, 110 (Jan. 1945).
[4] Hebb, M. H., and Nelson, E., *Phys. Rev.*, **58**, 486 (1940).
[5] Helmholz, A. C., *Phys. Rev.*, **60**, 160 (1941); **70**, 982 (1946).
[6] Bradt, H., Gugelot, P. C., Huber, O., Medicus, H., Preiswerk, P., and Scherrer, P., *Helv. Phys. Acta*, **18**, 256 (1945).
[7] Helmholz, A. C., *Phys. Rev.*, **60**, 415 (1941).
[8] Hebb, M. H., and Uhlenbeck, G. E., *Physica*, **5**, 605 (1938).

Spin and Wave Function of an Elementary Particle

I HAVE been able to show that there does not exist a mutually definite correlation between the spin and the transformation properties of the wave function of an elementary particle, as generally assumed. In particular, it will be seen that from the wave equation[1] quoted below there results for the electron a mechanical spin of the value $\pm \frac{1}{2}\hbar$ and a magnetic moment $e\hbar/2mc$, just as in the case of the Dirac equation, although in our example the components of the wave function do not transform as spinors do, and further, the wave equation is not Lorentz-invariant at all.

Let the wave equation be:

$$(\alpha_\nu \partial_\nu + \mu)\,\psi = 0, \tag{1}$$

where $\mu = mc/\hbar$, and the Greek suffices run from 1 to 4, ∂_ν means differentiation with regard to the νth-co-ordinate, and the operators α_ν should fulfil the following anticommutation rules:

$$\left.\begin{aligned} \alpha_i\alpha_k + \alpha_k\alpha_i &= \delta_{ik} \quad (i, k \neq 4) \\ \alpha_i\alpha_4 + \alpha_4\alpha_i &= \alpha_i \\ \alpha_4^2 &= \alpha_4. \end{aligned}\right\} \tag{2}$$

Application of the operator $(\alpha_\nu \partial_\nu - \mu)$ from the left to equation 1 yields, by means of (2):

$$\tfrac{1}{2}\Delta\psi - \mu\partial_4\psi - \mu^2\psi = 0,$$

that is:

$$\frac{\hbar}{i}\frac{\partial\psi}{\partial t} - \frac{\hbar^2}{2m}\Delta\psi + mc^2\psi = 0.$$

Hence, we may say that Schrödinger's dynamical equation of motion, in the absence of external fields, is a consequence of our wave equations (1). The only difference is in the last term, which represents the relativistic rest energy, but does not take any part in the following argument.

It can easily be seen that equation 1 is *not* relativistically invariant. On the other hand, one can prove that, by virtue of an algebraic lemma of Pauli and Artin[1], the operators α_ν have only one irreducible matrix representation, which has to be of rank four. This representation can be found without any trouble.

Now we proceed to the adjoint equation. Introducing the adjoint wave function by

$$\psi^\dagger = i\psi^* \gamma_4,$$

where ψ^* is the Hermitian conjugate of ψ and γ_4 is defined by $\gamma_4 = \Lambda - 2\alpha_4$, we get, after some calculation:

$$\partial_\nu\psi^\dagger \,.\, \alpha_\nu - \mu\psi^\dagger = 0. \tag{1a}$$

From (1) and (1a) one obtains by the usual methods an equation of continuity, which is fulfilled by a current-three-vector and an invariant density-expression, the latter being essentially positive definite.

All this shows the physical meaning of equation 1, and that it may describe an electron.

Now we may calculate the mechanical spin moment of the electron described by equation (1). Any one of the well-known methods leads to the result that the spin has the values $\pm \frac{1}{2}\hbar$, although, as mentioned above, the wave equation is not Lorentz-invariant and the components of ψ do not form a spinor.

Furthermore, taking into account an external electromagnetic field by substituting, as usual, $P_r = p_r - \frac{e}{c} A_r$ in place of $p_r \left(\equiv \frac{\hbar}{i} \partial_r\right)$, one obtains a magnetic moment of the value $eh/2mc$, that is, of one Bohr magneton. No electric moment appears, in contrast to the case of the Dirac equation; more precisely, the only eigenvalues of an electric moment are zero.

Finally, it may be mentioned that the Hamiltonian form of equation (1) can be obtained only by an artifice similar to that which Kemmer used[2]. Further, by aid of the proper Hamiltonian one can show that the eigenvalues of the velocity operator

$$\dot{x}_i = \frac{i}{\hbar} [H, x_i]$$

may have any real value. So the well-known difficulty appearing in the Dirac equation does not appear in the non-relativistic case.

Further investigations concerning the connexion of spin and wave function and the structure of the wave equation in the case of different particles are in progress.

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[1] van der Waerden, "Mod. Alg.", **2** (Springer, 1937).
[2] Kemmer, *Proc. Roy. Soc.*, A, **173**, 91 (1939).

Spectrum of Doubly Ionized Iodine

The spectrum of iodine excited to various stages of ionization by condensed discharges in capillary tubes of different cross-sections has been photographed by Littrow spectrographs in the visible and quartz regions. The use of a series inductance and spark gaps of different lengths helped in the selection of lines due to the doubly ionized atom of iodine. These results, supplemented by those of Blochs and Felici[1] in the far ultra-violet, facilitated the analysis of the main features of the structure of iodine III.

The important intervals $6s(^4P_{\frac{1}{2}} - {}^4P_{1\frac{1}{2}})$, $6s(^2P_{\frac{1}{2}} - {}^2P_{1\frac{1}{2}})$, and $6s(^2D_{1\frac{1}{2}} - {}^2D_{2\frac{1}{2}})$ were found to be 6,313, 11,254 and −1,609 wave numbers, respectively. About seven of the $6p$-levels, and six of the md-levels, have also been obtained. The calculation from the two members 130,615 ν and 19,306·7 ν of the mp^4S series identified in the present work leads to a value of 32·6 volts for the second ionization potential of iodine.

The normal Russel–Saunders coupling which is disobeyed in the $6s^4P$-intervals of the isoelectronic spectra of Sb I [2] and Te II [3] appears to be obeyed in this spectrum. However, Zeeman effect confirmation of the $6p$-term combinations with the $6s\ ^4P_{2\frac{1}{2}}$ level is being sought by further experiments.

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[1] *J. Phys. et le Rad.*, **8**, 355 (1937).
[2] Bacher and Goudsmit, "Atomic Energy States", 408.
[3] *Ind. J. Phys.*, **14**, 423 (1940).

Isolation of a Pectic Substance from Passion Fruit (*Passiflora edulis*)

An investigation was undertaken of the constituents of the skins of passion fruit (*Passiflora edulis*), the raw material being available from a processing factory in Sydney.

The ripe skins, from which the pulp had been removed by scooping, swell very much on heating with water and give a viscous extract. Extraction with water alone produces a liquid which can be freed from suspended matter only with great difficulty and considerable losses of material. Dilute acid, for example, 0·5 per cent citric acid, as recommended in the literature[1], and applied in the industrial practice of pectin manufacture, results in an extract which is readily handled from a colloidal point of view. Precipitation with alcohol or acetone gave a jelly-like product which on drying produced an amorphous substance. This material behaved like a pectin; it is a high-molecular substance and forms a jelly with sugar and acid; alkaline hydrolysis gave methyl alcohol and a high molecular acid. Its homogeneity was shown by the results of fractional precipitation with alcohol.

Final concentration of alcohol (%)	Uronic anhydride (%)	Equivalent weight
73	90·4	891
63	89·5	912
55	90·0	834
47	87·2	900

Another preparation was tested for homogeneity by repeated extraction with 70 per cent alcohol (boiling), when 28 per cent of substance dissolved; all extracts gave strong positive tests for uronic acid, indicating that the process not only removed a non-acidic, non-pectic 'balast' polysaccharide. The contents of the product before and after the extraction are:

	Uronic anhydride (%)	Equivalent weight before saponification	Equivalent weight after	OME	$[\alpha]_D$
Before extraction	82·4	1198	251	9·75	+208°
After extraction	84·4	1515	276	9·6	+272°

It therefore appears as if this operation essentially removes the lower molecular portion of the material and not 'balast'.

The material is rather resistant to hydrolysis, for after two hours heating in a water bath with $5N$ sulphuric acid it is not completely broken down to monomeric sugars. Complete hydrolysis was easily effected enzymatically with 'Pectinol 100D' (Rhöm and Haas, Philadelphia, U.S.A.[2]), and the following constituents were isolated and identified: d-galacturonic acid, $[\alpha]_D + 49·7°$, l-arabinose as the diphenylhydrazone and l-sorbose as the phenyl-osazone. This pectic substance is therefore unlike any previously described, as it contains no galactose[3] but does contain l-sorbose, which is a novel constituent for this class of substance.

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[1] Wilson, P. P., *Indust. Eng. Chem.*, **17**, 1065 (1925). Rooker, W. A., "Fruit Pectin" (Avi, New York). Nelson, E. K., and Mottern, H. H., *Fruit Prod. J.*, **10**, 138 (1931). Meyers, B. B., and Baker, G. L., Delaware Agric. Expt. Sta. Bull. Nos. 160 and 168.
[2] Meyers, B. B., and Baker, G. L., Delaware Agric. Expt. Sta. Bull. No. 168.
[3] Joslyn, M. A., and Phaff, Wallerstein Lab. Com., **10**, No. 29 (April 1947).

Extraction of Fibrinolytic Enzyme from the Blood

FIBRINOLYTIC activity of the blood *in vivo* has been seen in the course of liver diseases[1], in toxæmia of pregnancy[2], in shock[3], in violent death[4], during surgical operations[5,6], during the preparation of operations[7] and in the course of resorption of thrombi[8]. The fibrinolytic enzyme may be activated *in vitro* by chloroform and by by-products of the metabolism of hæmolytic streptococci[8,9].

Another possible method of activation is indicated by the results reported by Schmitz[10], who demonstrated the presence of proteolytic activity in the precipitate obtained from serum treated with trichloracetic acid. It is not known whether this process activates the enzyme and removes an inhibitor. This experimental result, combined with the fact that all investigators agree that the enzyme or the substance giving rise to it should be sought for among the globulins, indicates another and more promising method of concentration. This process, which has been tried with success, is as follows.

The euglobulins are precipitated from pig plasma by dilution with distilled water followed by saturation with carbon dioxide. After separation the euglobulins are dissolved in $N/10$ acetic acid and the solution brought to *p*H 1–1·2 with $2N$ hydrochloric acid; any precipitate which may appear does not interfere. Next, four times the amount of ice-cold acetone (brought to *p*H 1 with a few drops of $2N$ hydrochloric acid) is added and the precipitate which forms removed by centrifuging. This acid precipitation brings about simultaneous activation (or removal of the inhibiting substance). The process corresponds to the dissociation of the trypsin : trypsin-inhibitor compound in a strong acid medium. The inhibiting compound has a relatively low molecular weight and probably remains in solution during the precipitation with acetone. In order to purify it further, the precipitate is re-dissolved in $N/10$ acetic acid. A gel frequently forms at this stage which becomes liquid again on the further addition of acetic acid. N sodium hydroxide is next added, the optimal *p*H being 5, and a precipitate forms, which can be removed by centrifuging strongly. To the decanted liquid is now added four times its volume of ice-cold acetone, and the resulting precipitate is separated by centrifuging. The precipitate is divided up finely, mixed with an amount of veronal acetate buffer (*p*H 4·92) corresponding to half the original volume of plasma and extracted for half an hour in a cold-room, on the shaking machine. The buffer, which takes up the enzyme, is filtered off and dialysed for twenty-four hours in the cold-room against distilled water, which is frequently changed and the *p*H of which is adjusted to about 1·2. Next, isoelectric precipitation (at *p*H 6) is carried out by careful addition of $N/10$ sodium hydroxide. The precipitate, which contains the enzyme in a very concentrated form, is rapidly dried in a high vacuum. It is obtained as whitish- to yellowish-brown lamellæ which can be easily powdered.

The powder is stable for months when kept in a closed bottle at room temperature. It is almost insoluble in water but dissolves well in a slightly alkaline solution of sodium chloride (1–2 per cent). Such solutions rapidly lose their activity at room temperature. On the other hand, they can be injected. Thus, 400 mgm. dissolved in 10 ml. of common salt solution and injected intravenously into a 2-kgm. rabbit brings about a spontaneous lysis of a sample of plasma (diluted 1 : 20 and recalcified) from the animal. With concentrated preparations this phenomenon, which takes place within eight to twenty-four hours with a sample kept in the thermostat, can still be demonstrated several hours after injection. A 1 per cent solution containing 1–2 mgm. added to 1 ml. of human citrate plasma before coagulation brings about the re-liquefaction within a few hours of the clot formed on re-calcification. The preparation is relatively slowly inactivated in plasma or serum. The action of the enzyme in fibrin, left in its own serum, is considerably stronger than that on gelatin, as revealed by the change in viscosity of a gelatin solution, whereas trypsin rapidly breaks down gelatin under the same conditions but without having any action on the untreated clot.

The products obtained do not always have the same activity. The method of preparation described is most successful with pig or horse plasma. Ox plasma gives distinctly poorer yields. The plasma should be worked up within a day or two of its preparation. The action of the enzyme in overcoming the anti-fibrinolytic property of the blood seems to be particularly outstanding.

Because of its method of preparation, the name 'acido-plasmin' is suggested for the enzyme. Further investigations are in progress.

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[1] Goodpasture, E. W., *Bull. Johns Hopkins Hosp.*, **25**, 330 (1914).
[2] Smith, O. W., and Smith, G. V. S., *Science*, **102**, 253 (1945).
[3] Tagnon, H. J., *J. Lab. and Clin. Med.*, **27**, 1119 (1942).
[4] Yudin, S. S., *Presse Med.*, **44**, 68 (1936).
[5] MacFarlane, R. G., *Lancet*, I, 10 (1937).
[6] v. Kaulla, K. N., *Schw. med. Wschr.*, **77**, 313 (1947).
[7] Macfarlane, R. G., and Biggs, R., *Lancet*, 862 (1946).
[8] Christensen, L. R., and MacLeod, C. M., *J. Gen. Physiol.*, **28**, 559 (1945).
[9] Loomis, E. C., George, C., and Ryder, A., *Arch. Biochem.*, **12**, 1 (1947).
[10] Schmitz, A., *J. Physiol. Chem.*, **25**, 37 (1937).

Fungi as Indicators of Soil Conditions: Soil Fungi from South Africa

AN attempt has been made, by the isolation of fungi from the upper six inches of soil, to determine differences in a series of experimental plots in the Transvaal Highveld, on the Frankenwald Experimental Station, attached to the University of the Witwatersrand. The area was constant in its soil type, which was granitic in origin, sandy, lacking organic matter, and with a *p*H of about 4·5. The grass cover was fairly uniform. The area was made up of plots which had been, for the past seven years, subjected to different cultural treatments. One had been burnt and afterwards lightly grazed; a second burnt and heavily grazed; a third burnt but not grazed; a fourth, control plot, was neither burnt nor grazed. The treatment had been continuous, the various phases alternating at regular intervals.

Using Waksman's method[1], the occurrence of fungi from the four plots could be grouped as follows:

	Burnt and lightly grazed	Burnt and heavily grazed	Burnt only	Control
Phycomycetes	8	8	2	4
Ascomycetes	5	3	1	3
Fungi Imperfecti	6	2	8	5

Samples were taken from the field over a period of thirteen months. The number of times for the occurrence of each species is not indicated in the above table.

A new method, rather similar in conception to one recommended by Winogradski[2] for bacteria, but with which I was not familiar at the time, was also used. Small samples of about 250 gm. were made up from the experimental plots (which were relatively circumscribed in area), and were kept at 40 per cent of their determined maximum water-retaining capacity, at room temperature. They were sampled in the usual way at regular intervals.

Tabulation of the various species which were isolated is given as follows:

	Burnt and lightly grazed	Burnt and heavily grazed	Burnt only	Control
Phycomycetes	5	2	5	3
Ascomycetes	5	6	6	4
Fungi Imperfecti	7	6	7	6

While the work was essentially of a preliminary nature, it was felt that the results obtained were sufficient to indicate that soil fungi may be used as indicators of conditions within the soil, resulting from the cultural treatments employed. Apart from much that is highly suggestive, tentative conclusions based on the results obtained from both sets of isolations might be that burning followed by light grazing is the best, or least harmful, of the treatments used; that burning is harmful, directly or indirectly, but that if the veld has to be left ungrazed it may be burnt (subject to certain precautions which cannot be dealt with here). Such generalized conclusions would be in accordance with those obtained by a variety of methods already used, such as phenological observation; mapping by means of fixed quadrats; pasture yields and cattle weights; the maintenance and transfer of root reserves in relation to the severity of grazing, and so on. The evidence is as yet insufficient to predict the possible roles of individual species.

The 'incubation' method appeared to hold possibilities for a variety of experimental purposes, apart from its use here in supplementing and correcting the results obtained from the field samples, particularly in the case of burning with no grazing, and the increase in the number of Ascomycetes.

As this is the first record of soil fungi from South Africa, a list of species isolated is given, the authority being Gilman's "Manual of Soil Fungi"[3] for all the known forms.

PHYCOMYCETES: *Circinella tenella* Zycha; *Cunninghamella berthellatia* Stadel; *Cunninghamella echinulata* Thaxter; *Cunninghamella elegans* Lendner; *Cunninghamella* sp.; *Dissophora decumbens* Thaxter; *Mortierella renispora* Dixon-Stewart; *Mucor* c.f. *adventitius* Oudemans; *Mucor albo-ater* Naumov; *Mucor* c.f. *corticolous* Hagem; *Mucor janssenii* Lendner; *Mucor microsporus* Namylowski; *Mucor petrinsularis* Naumov; 2 *Mucor* spp.; *Pythium* spp.; *Rhizopus arrhizus* Fischer; *Thamnidium elegans* Link; *Thrautotheca* c.f. *irregularis* Coker and Ward.

ASCOMYCETES: *Aspergillus fumigatus* Fresenius; *Aspergillus niger* van Tieghem; *Fimetaria fimicola* Griffiths and Seaver; *Fimetaria* c.f. *sylvatica* Griffiths and Seaver; *Nectriella* sp.; *Penicillium aurantiobrunneum* Dierckx; *Penicillium citrinum* Thom; *Penicillium flavidorsum* Biourge; *Penicillium* c.f. *griseoroseum* Dierckx; *Penicillium intricatum* Thom; *Penicillium spinulosum* Thom; *Penicillium stoloniferum*? Thom; *Penicillium sublateritium* Biourge; 3 *Penicillia* spp.; *Rosellinia* sp.; *Pseudogymnoascus* sp.; *Torula* sp.

FUNGI IMPERFECTI: *Acremonium vitis* Cattaneo; *Acremonium* sp.; *Botrytis pyramidalis* Saccardo; *Cephalosporium* c.f. *acremonium* Corda; *Cephalosporium curtipes* Saccardo; *Dactylium* sp.; *Fusarium nivale* Cesati; *Fusarium* sp.; *Hyphoderma* sp.; *Mycogone alba* var. *minor* Raillo; *Oospora variabilis* Lindau; *Schlerotium* sp.; *Scopulariopsis* c.f. *roseum*?; *Trichoderma album* Preuss; *Trichoderma glaucum* Abott; *Trichoderma koningi* Oudemans; *Trichoderma lignorum* Harz; *Verticillium glaucum* Bonorden.

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[1] Waksman, S., *J. Bact.*, **7**, 339 (1922).
[2] Winogradski, S., *Proc. 1st Int. Cong. Microbiology*, **1**, 110 (1930).
[3] Gilman, J., "Manual of the Soil Fungi" (Iowa State College Press, 1945).

Multiovular Follicles in the Ovaries of Lower Primates

EXAMINATION of the ovaries of some of the lower primates has revealed the presence of numbers of multiovular follicles and multinuclear oocytes. Multiovular follicles have occasionally been reported in the ovaries of a great variety of animals; but there has been no specific reference in the literature to their occurrence in the species mentioned below. Hartman[1] found an abundance of multiple follicles in the opossum ovary; some follicles contained up to a hundred oocytes, and many oocytes were found with two to eight nuclei. Recently, I reported[2] the presence of multiple follicles in the goat ovary; they were found to be mainly associated with œstrus and also occurred during a certain period in early pregnancy.

Ovaries of six specimens of *Saimiri sciurea* were examined; the ovaries of four of these animals were in the late follicular phase of the ovarian cycle. Counts were made of a thousand oocytes in each ovary and revealed 7 per cent binuclear, 2 per cent trinuclear oocytes, 12 per cent binovular and 3 per cent triovular follicles. The third and fourth specimens were in the luteal phase of the ovarian cycle, judging by the appearances of the corpus luteum and the uterine mucosa; fewer multiple follicles were present and many were atretic.

The ovaries of two *Lemur macaco* were also examined. The first animal died on arrival in Great Britain in 1947. Both ovaries contained many atretic multinuclear oocytes and multiovular follicles. No counts could be made owing to the extensive atresia. The second lemur lived for thirteen months at Chessington Zoo and is said to have been healthy until it died of acute bronchitis during June 1948. The cortex of both ovaries contained a large number of oocytes and primary follicles, many of which were multiovular. Larger follicles up to 0·5 mm. in diameter were present; some contained as many as five oocytes. Counts of a thousand follicles showed the presence of 20 per cent binovular, 6 per cent triovular, and 4 per cent multiovular follicles containing between five and eleven oocytes. Ovaries of the following were also examined: *Tarsius spectrum* (one specimen, due to the kindness of Prof. Le Gros Clark), *Galago senegalensis* (1), *Ateles ater* (3), *Cercopithecus æthiops* (2), *Papio porcarius* (3). The number of binuclear oocytes and binovular follicles was limited to only two or three in each ovary.

The majority of the multiple forms in all the ovaries showed either early or advanced signs of atresia. In many oocytes, in which the zona pellucida

had not developed, small groups of granulosa cells had invaded the ooplasm; this phenomenon has been observed by Asami[3] in the rabbit ovary and by myself[2] in the goat ovary. Hartman[1] has suggested that multiple-follicle formation represents an atretic phenomenon. Bacsich[4] has observed multiple follicles in new-born and infant ovaries. He believes their presence to be due to the withdrawal of gonadotrophic hormonal influences. I have suggested[2] that their presence in the goat ovary is related to excessive œstrogenic stimulation. It is probable that multiovular follicles and multinuclear oocytes do represent atretic changes, although, as Corner's[5] findings in the sow ovary indicate, a multiovular follicle may reach maturity and ovulate. However, the precise cause of multiple follicle formation has still to be demonstrated.

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[1] Hartman, C. G., *Amer. J. Anat.*, **37**, 1 (1926).
[2] Harrison, R. J., *J. Anat.*, **82**, 21 (1948).
[3] Asami, G., *Anat. Rec.*, **18**, 323 (1920).
[4] Bacsich, P., *J. Anat. Lond. Proc.*, **80**, 243 (1946).
[5] Corner, G. W., *Amer. J. Anat.*, **31**, 523 (1923).

Opalinids from Nile Fish

The Opalinids are a very isolated group of Protozoa the relations of which to their normal amphibian hosts have been taken as indicating a high degree of specialization resulting from an association of great antiquity. A slowly growing number of records from non-amphibian hosts, namely, four species of reptiles, three of fish and one mollusc, however, appears inconsistent with this conclusion.

A recent examination of the alimentary canals of various fish both from the Khartoum neighbourhood and from the Upper White Nile (Malakal to Lake No) has shown that these ciliates are commonly present in the intestines of no fewer than eight additional species belonging to the Siluroids and Citharinids. There is no question of merely casual infections. In almost every case the ciliates were present in immense numbers, as in maximal infections of batrachians. A summary of the observations on these two groups of fish is given below.

	Number examined	Opalinids present in	Other ciliates present in
Siluroidea			
Schilbeidæ			
Eutropius niloticus	6	4	6
Schilbe mystus	11	6	7
S. uranoscopus	7	0	0
Mochocidæ			
Synodontis clarias	4	1	1
S. frontosus	4	2	2
S. membranaceus	16	9	11
S. schall	12	4	5
Clariidæ and Bagridæ	18	0	0
Citharinidæ			
Distichodus spp.	6	0	0
Citharinus citharus	7	6	5
C. latus	2	1	0

No ciliates were found in fifty-three other fish belonging to the Characinidæ, Cyprinidæ, Mormyridæ, Gymnarchinæ, Centropomidæ, Osteoglossidæ, Cichlidæ and Tetrodontidæ.

The following points merit comment. (*a*) The "other ciliates" were species of *Balantidium* and, less commonly, of *Nyctotherus*. It is striking that among these fish, with the exception of *C. latus*, every species and usually every individual that harboured Opalinids harboured also these other ciliates and *vice versa*. The resulting intestinal fauna is thus extremely similar to that of the Anura. There is consequently no question of any special conditions favouring the presence of Opalinids, but rather of conditions favourable to ciliate infection in general.

(*b*) There is at present no evidence as to the nature of these conditions; but they appear to be strangely independent of both the systematic position and the general ecology of the fish. Of the previously recorded piscine hosts, two, namely, *Box boops* and *Gadus capelanus*, are marine Mediterranean fish belonging to quite different orders (Percoidea and Anacanthini respectively). The third, *Pimelodus* sp., is a freshwater Siluroid from Paraguay; but its nearest African relatives, the Bagridæ, have been found to be quite free from ciliates. Among the new hosts, the two species of *Citharinus* are mud-eaters; most of the infected individuals of *S. membranaceus* had their alimentary tracts gorged with planktonic Crustacea, while the other species of *Synodontis* and the Schilbeidæ are more or less omnivorous but include both predominantly surface-feeding and predominantly bottom-feeding types. Strangest of all is the complete absence of ciliates from *S. uranoscopus*, in spite of its very close resemblance in structure, habits and distribution to *S. mystus* and *Eutropius niloticus*.

(*c*) Most of the host species contained more than one species of Opalinid, among which various types of Protoopalina were most common. None of the broad multinucleate Opalinas was found; but typical Zelleriellas were found in *C. latus*. This genus has only twice previously been recorded from the Old World, namely, once from Nanking and once from Cape Town.

Descriptions of the ciliates will be published later.

H. Sandon

Gordon Memorial College,
Khartoum.
March 17.

'Data'

I once succeeded, by a letter to *Science*[1], in stopping American scientific people from hypothecating (that is, pawning) when they intended to advance a hypothesis. Would you allow me to protest against the common confusion of another word? 'Data' is the plural of 'datum', defined in the Shorter Oxford English Dictionary as "A thing given or granted; something known or assumed as a fact, or made the basis of reasoning or calculation". There may sometimes be an excuse for regarding 'data', like 'agenda', as a collective singular; there is none for using it in a sense the exact converse of its proper one. The 'data' of an experiment or investigation are not the results that come out of it, any more than the agenda of a committee meeting are its recommendations. Why not let 'data' go on meaning (as it has meant since 1646) the facts and figures assumed at the start, not those which appear at the end?

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Aug. 5.

[1] *Science*, **85**, 605 (1937).

SALT LINKAGES IN PROTEINS

By C. F. JACOBSEN and K. LINDERSTRØM-LANG
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THE original conception of Speakman[1-3] that salt linkages are important structural elements in micelles of fibrous proteins like keratin has been extended more recently[4,5] to include molecules of globular proteins in aqueous solution. Although there is some vagueness with respect to the exact physical character of the linkages in question, their hypothetical properties as outlined by Eyring and Stearn[5] seem to classify them as hydrogen bonds between the ionizable amino and carboxylic groups of the side-chains of amino-acids (Mirsky and Pauling[4]). In such bonds the close approach of the opposite charges makes them appear as essentially neutral to the surroundings, and their instability in the presence of water requires that they are in protected positions inside the protein molecule[4]. Still, they are supposed to react with protons, and in Eyring and Stearn's theory[5], therefore, any protolytic reaction of a dissolved protein involves the breaking or formation of hydrogen bonds between carboxylic and amino groups. Since these bonds are regarded as characteristic of native proteins as distinct from denatured ones[4,5], there is supposed to be an element of denaturation and renaturation in all protolytic reactions.

In our investigations on the volume change accompanying the reaction of dissolved proteins with protons, we have found little support for the above theory. In fact, the twenty-years old pioneer work of Weber and Nachmannsohn[6,7] (compare also the work of the Boston School[8]) had already removed a great deal of the basis upon which Eyring and Stearn's conception is built. Weber's investigation, which is based upon Bjerrum's fundamental paper of 1923[9], resulted in a convincing demonstration of the fact that by far the greater part of the charged amino and carboxylic groups of a soluble protein are free and surrounded by water in the neighbourhood of the isoelectric point. His line of argument was as follows.

The protolytic reaction

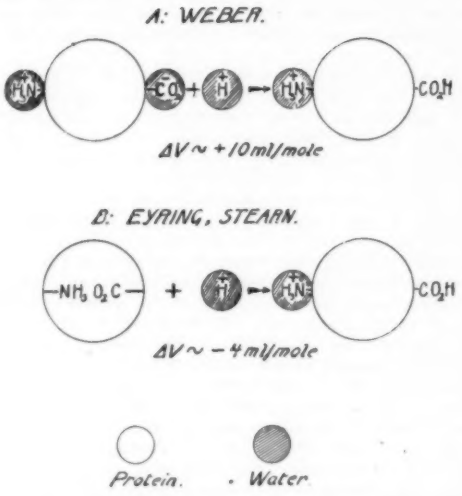
$$R - COO^- + H_3^+O \rightarrow R - COOH + H_2O$$

is accompanied by a volume change ΔV of + 10 to + 12 ml. per mole as shown in experiments with simple compounds. When, on the other hand, isoelectric, acidic proteins (ovalbumin, serum albumin) are mixed with acid (hydrochloric), values for ΔV of + 8 to + 10 ml. per mole acid bound are found.

Similarly, the reaction

$$R - NH_2 + H_3^+O \rightarrow R - NH_3^+ + H_2O$$

is followed by a volume change of − 2 to − 6 ml. per mole, but the agreement with the values found for proteins is less satisfactory here because other ionizable groups such as —OH in tyrosine and —SH in cysteine interfere. Restricting, therefore, our considerations to the acid region of the protein titration curve, where the ionization of residual NH_2 groups, present in the isoelectric molecule, plays a less dominant part, the situation may be visualized as in the accompanying scheme, provided that in both processes we can neglect volume changes originating in phenomena other than electrostriction. Under these conditions there is no doubt that the conception underlying *A* should be preferred.



However, in the Eyring–Stearn protein model (*B*), the hydrogen bond formation might be imagined to cause a sufficiently close packing of the atoms of the protein molecule to explain a dilatation upon denaturation of 14 ml. per mole hydrogen bond, which would make the two values of ΔV identical. In order to illustrate this problem, we may let a small crystal of an amino-acid or peptide represent a protein molecule with its hydrogen bonds, and consider its reaction with aqueous acid. From data in the literature[8] and from direct experiments, the following results are obtained:

$$(\text{glycine})_{solid} + H_3^+O + nH_2O \rightarrow (\text{glycine}^+)_{dissolved} + (n+1)\,H_2O \qquad \Delta V = +4{\cdot}0$$

$$(\text{DL-alanylglycine})_{solid} + H_3^+O + nH_2O \rightarrow (\text{DL-alanylglycine}^+)_{dissolved} + (n+1)\,H_2O \qquad \Delta V = +3{\cdot}5;$$

and hence in spite of the unusually close packing of the atoms in the crystals of these substances[10] the dilatation effect is found to be too small to account for the difference mentioned.

According to Svedberg[11], carefully dried gelatin gives a considerable volume *contraction* upon solution in acid, which indicates a much looser packing. The same is true for dried β-lactoglobulin crystals.

Volume change accompanying the binding of hydrogen ions by lactoglobulin in 0·1 *N* potassium chloride. (Protein concentration 26·3 mgm./ml.) Initial *p*H 5·20 (isoelectric point).

Final *p*H	Number of groups ionized per molecule (M_w = 40,000)	ΔV ml./proton bound
4·44	10·8	+11
3·74	21·0	+12
3·16	31·2	+11
2·13	45·3	+11

As an example of more recently studied protolytic reactions, we may quote a few protein experiments with β-lactoglobulin (compare refs. 12, 13, 14). The accompanying table illustrates the kind of results obtained. Since titration and amino-acid

analysis[11,13,14] in excellent agreement lead to the value 49 for the total number of proton-accepting groups in isoelectric β-lactoglobulin, there seems little room for salt linkages of the type assumed by Eyring and Stearn. It is noteworthy in this connexion that β-lactoglobulin is very stable in acid solution and can even be recovered in crystalline form from trichloroacetate precipitates (Jacobsen, unpublished work).

Another group of observations which are unfavourable to the salt-linkage theory in its modern form have been made in this Laboratory in connexion with previously reported experiments[12] on the volume-change accompanying the enzymatic breakdown of β-lactoglobulin by trypsin and chymotrypsin. While the anomalously high contraction in the enzymatic process at *p*H 8 might be, but was not, explained[12] by taking into account the additional electrostriction around ions liberated from salt-linkages in the deep degradation of the protein molecules, a similar explanation is not possible for the peptic process which takes place at a *p*H of about 2, where the salt-linkages are assumed to be broken already. Still, the anomaly is here of the same order of magnitude as at *p*H 8, the volume change found being about −30 ml. per peptide bond broken against the theoretical −6 ml. (compare ref. 15).

On the basis of the above facts alone, we feel justified in excluding the hydrogen bond between polar side-chains as an essential structural element in the β-lactoglobulin molecule in solution. Experiments with other proteins tend to show that this conclusion may be general for globular proteins. Another matter is that electrostatic forces between the hydrated ion pairs in proteins may have an influence upon the stability of their molecules; but in our opinion this influence would only be significant if the average distance between the ions of these pairs were so small that ΔV for the binding of protons should fall essentially below the experimental value of c. 10 (see refs. 6, 7, 12). We must therefore look elsewhere for a general explanation of the stability of the molecules of proteins in solution.

In the rapidly accumulating experimental material concerning the properties of proteins[8], we have found little evidence against our point of view, and if it were not for the fact that, to our knowledge, no explicit criticism of Eyring and Stearn's hypothesis has been offered, we would have been satisfied that Weber's ideas were generally accepted. However, a discussion of this important question may be of value at the present stage of the development of protein chemistry.

[1] Speakman, J. B., and Hirst, M. C., *Nature*, **128**, 1073 (1931).
[2] Speakman, J. B., and Scott, E., *Trans. Farad. Soc.*, **30**, 539 (1934).
[3] Speakman, J. B., and Townend, F., *Trans. Farad. Soc.*, **32**, 897 (1936).
[4] Mirsky, A. E., and Pauling, L., *Proc. U.S. Nat. Acad. Sci.*, **22**, 439 (1936).
[5] Eyring, H., and Stearn, A. E., *Chem. Rev.*, **24**, 253 (1939).
[6] Weber, H. H., and Nachmannsohn, D., *Biochem. Z.*, **204**, 215 (1929).
[7] Weber, H. H., *Biochem. Z.*, **218**, 1 (1930).
[8] Cohn, E. J., and Edsall, J. T., "Proteins, Amino-acids and Peptides", 155–195 (Reinhold Pub. Corp., New York, 1943).
[9] Bjerrum, N., *Z. physik. Chem.*, **104**, 147 (1923).
[10] Albrecht, G., and Corey, R. B., *J. Amer. Chem. Soc.*, **61**, 1087 (1939).
[11] Svedberg, T., *J. Amer. Chem. Soc.*, **47**, 2673 (1924).
[12] Linderstrøm-Lang, K., and Jacobsen, C. F., *C.R. Lab. Carlsberg, Sér chim.*, **23**, 179 (1940).
[13] Linderstrøm-Lang, K., and Jacobsen, C. F., *C.R. Lab. Carlsberg, Sér chim.*, **24**, 1 (1941).
[14] Jacobsen, C. F., *C.R. Lab. Carlsberg, Sér. chim.*, **26**, 455 (1949).
[15] Brand, E., *Ann. New York Acad. Sci.*, **47**, 187 (1946).
[16] Haugaard, G., and Roberts, R. M., *J. Amer. Chem. Soc.*, **64**, 2664 (1942).

SOME UPPER LIMITS OF POSSIBLE ALPHA-ACTIVITY

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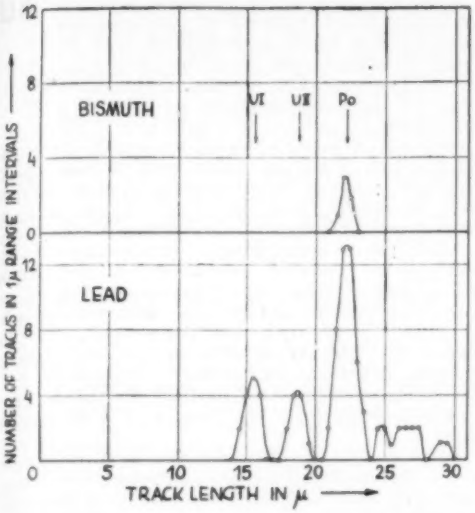
WITH the single exception of samarium-152 [1], no α-ray emitter of nuclear charge smaller than 83 is known. On the other hand, it is concluded from the general trend of the mass-defect curve that many heavy nuclei must be unstable against α-decay. Circumstantial evidence for the existence of α-ray emitters hitherto unknown is provided by certain pleochroic haloes[2] and, possibly, by 'excess helium' in minerals, notably beryl[3]. The difficulty in identifying additional α-active nuclear species must be due to the slowness of their decay, or to their low abundance in the natural elements.

Apparently no sensitive determinations of limits of α-activity have been carried out in experimental conditions where sharp discrimination against the effect of radioactive contamination of the investigated material, of the support or of the walls of the measuring instrument is possible[3,4]. Polonium, in particular, is generally present as a contaminant. We wish to report here experiments by a photographic plate method. The full lengths of the α-ray tracks in the emulsion can be measured in every single case so that confusion with polonium, etc., is excluded; the material under investigation is effectively present as a layer of zero thickness. Moreover, the sensitivity of the method is unequalled.

Ilford Nuclear Research plates (*C2*; thickness 50 or 100 μ) were impregnated with various ions by bathing in solutions of suitable salts for 30 min. at 18° C. After impregnation, the plates were rinsed superficially, dried in air, kept for periods up to seven months, developed, and the lengths of the α-tracks which had appeared were measured in the usual way. Only plates in which no marked desensitization or fading had occurred were evaluated; a check on this was obtained by covering with thorium oxide the surfaces of a set of control plates for a short time immediately after drying, and observing, after the period of keeping, the grain densities of the tracks thus formed. It was found that the emulsion is desensitized by hydrogen ions. Therefore neutral solutions were preferred; when for chemical reasons acid solutions had to be used, the impregnated plates were given an after-treatment in dilute ammonia ($\sim 0{\cdot}002\ M$) before drying. In plates considered satisfactory, the grain density had not decreased more than 20 per cent compared with the density of fresh tracks in non-desensitized emulsions. A grain loss of 20 per cent does not shorten the mean track-lengths by more than a small fraction of a micron.

All plates contained tracks due to contamination. The accompanying diagram gives the spectra of plates loaded with lead and bismuth. Stars, due for example to radiothorium, as well as single tracks of more than 30 microns, have been neglected. Tracks from uranium and polonium are seen to be present; the few longer tracks in the plate loaded with lead are probably tracks of descendants of thorium and/or tracks of polonium produced while the emulsion was wet. Generally speaking, there is no danger of range coincidence between radiations from contaminants and from unknown emitters. The shortest tracks from any member of the radioactive



series (thorium—energy, 4·20 MeV.; range, 2·60 cm. air) were found to be 15·4 μ long. On the other hand, it is calculated from Gamow's equation that even in extremely unfavourable circumstances (assuming a decay constant $\lambda = 10^{-21}$ sec.$^{-1}$ and a nuclear radius 7×10^{-13} for the most highly charged among the nuclei under investigation, namely, bismuth-209) the α-ray energy would be only about 3·8 MeV., corresponding to a range in air of about 2·3 cm., and in the emulsion of about 13·6 μ. The best-defined unidentified pleochroic halo has a range equivalent to 1·8 cm. air.

The relation between the half-life $\tau_{1/2}$ and the number of tracks N, counted in n (usually 1,000–2,000) fields of view under the microscope, each of volume v, after keeping the plate for a time t, is

$$\tau_{1/2} = \frac{nvcfAt \ln 2}{N},$$

if c is the concentration of the impregnating solution in gram-atoms/c.c. (usually about 5×10^{-5}), and A is Avogadro's number. The 'penetration factor' f is defined as the ratio of the concentrations in the dry emulsion and in the solution. Its value for each individual case is rather roughly estimated from a series of tests performed with α-emitters of known half-lives, where penetration can be derived directly from track counts. The following test substances were used: thorium B, giving tracks of thorium C or C′; radium in mixture with barium; uranium as uranyl salt, giving tracks of uranium I and II; samarium; thorium + radiothorium. The value of f depends on valency, nature of the anion, conditions of bathing, etc. The most potent influence, however, is that of pH, in the sense that much more material is taken up from neutral than from acid baths. Penetration factors of 2–4 were found to apply with solutions of pH 6 containing 1 per cent of salt—about the highest concentration compatible with good quality of the tracks. Finally, the volume v (about 10^{-6} c.c. for 100-μ plates) is obtained as the volume of the cylinder of emulsion constituting one field of view, minus the volumes of the upper and lower border zones, in which the true lengths of inclined tracks may remain unknown.

With most elements tested, including lead and bismuth, no unidentified tracks were obtained. In these cases, to give a figure for the limit, we put $N < 1$. In a very few cases, which are being further examined, there was a small number of tracks which we have not yet identified; in these cases we also put $N < 1$, but insert for n the average number of fields of view required to find one track of this kind. Some results are listed in the accompanying table.

Element	Salt used	Half-life (years) ($\times 10^{-15}$)
Mo	ammonium molybdate	> 9
Rb	rubidium chloride	> 17
Zr	zirconium oxynitrate	> 2
Cd	cadmium sulphate	> 6
Pb	lead nitrate	> 3
Bi	bismuth ammonium citrate	> 3
Sm (for comparison)	—	0·0010
Th (for comparison)	—	0·000014

From a search of non-impregnated plates, the conclusion is drawn that the half-lives of silver and bromine, which are present in very high concentrations, exceed 10^{18} years.

The investigation is being extended to other elements. In addition, the limits are being improved through various modifications of the procedure. A fuller account is in preparation.

We would like to thank Prof. Karl Przibram for his help and his interest in our work.

[1] Dempster, *Phys. Rev.*, **73**, 1125 (1948).
[2] See Schintlmeister, *Wiener Ber.*, **145**, 449 (1936). Henderson, *Proc Roy. Soc.*, A, **173**, 250 (1939).
[3] Glückauf and Paneth, *Proc. Roy. Soc.*, A, **165**, 283 (1938).
[4] Libby, *Phys. Rev.*, **44**, 512 (1933).

CINEMATOGRAPHY AND THE UNIVERSITY

By C. DENIS PEGGE
Cambridge University Educational Film Council

IN one or two universities, bodies have been instituted to foster the use of educational films; and to serve the interests of all British universities a national Universities Film Council was founded in October 1947. In the course of an article—which must necessarily repeat some things that might be said regarding school education—it is hoped to indicate how various are the ways in which a university may be concerned with films.

Education consists largely of literal and symbolic interpretations of reality, or of man's experience of it. One general function of visual aids is to supplement these interpretations with what as nearly as possible provides direct experience, where that experience cannot otherwise be provided, or cannot conveniently be provided. Also films supply matter for visual memory—which is more retentive than aural memory. Wherever there is movement or growth, films may illustrate it. Leaving aside the possibilities of stereoscopic film, relative movement between object and camera allows solidity to be shown—of use, for example, in a study of crystal forms. Often it may not be possible to provide university students with direct experience of a process or phenomenon—the manufacture of steel, the development of an embryo, or the failure of a bridge. In other cases the special devices of photography—allowing selection of viewpoint, lighting and time—can permit optimum presentation of a subject to a large class. Moreover,

cinematograph films provide the only means of presenting movement that is either too rapid or too slow to be perceived through normal vision.

In advanced teaching the provision of what have sometimes been called 'animated lantern slides', the mere provision of moving photographs, will probably remain of first importance. But, as everyone knows, the film can supply a visual language.

Apart from providing illustration in teaching, the film may be used for directing attention to a particular subject or problem, and for stimulating interest in it.

Shots are related to one another in a sequence; the effect of each shot is influenced by the effects of the shots which come before and after, and there is a sum-total of effect from all the shots. It is appropriate that the closeness of the illusion of reality allowed by moving photographs should have been exploited in the silent film of 20–30 years ago. 'Elements of reality' may be the syllables and words of the language of film. Whether from the rudimentary 'animated lantern slide' or from the developed montage film like Pudovkin's "Mechanics of the Brain", it is its quality of being able to provide direct experience that makes the widely various film medium mainly valuable in education. Also it is through sight that the film makes its unique contribution. In embodying speech, films supply what lectures and books can also supply. Nevertheless, the sound film and the talking film are in common use. The film has often been classed, therefore, as a visual-aural aid. Indeed, it is as an aural aid that it is of considerable value in the teaching of languages. For example, at one university recently a series of some six film sessions—each about two hours long—was arranged for students of the Russian language, a number of outstanding Russian talking films being shown, including "Ivan the Terrible", "General Suvurov", "Lone White Sail" and "My Universities".

Another important class of films in teaching are those embodying animated diagrams, and many other classes of films might be designated. But a great variety has been indicated.

In the presenting of these films in university teaching there may broadly be distinguished two main methods. The film may be used as an integral part of a lecture, illustrating the lecture directly and dominated by the lecturer's presence. This is the most usual and probably most valuable method. It is the one most frequently employed in schools. Partial black-out—and, if attainable, daylight projection—are desirable for this manner of presentation.

The other main method is to show films in a separate cinema period. This is suitable for the showing of what may be termed 'background' films, and for practical reasons may be a convenient way of showing films that illustrate current lectures. Although introductions may play a very valuable part, the introducer will not dominate as in the lecture method. The screen, generally speaking, is allowed to take charge. It is important, therefore, when using this method that the black-out should be complete and the projection arrangements perfect. The films will be arranged to link as closely as possible with the subject-matter of lectures and laboratory work. But an important function that the provision of a cinema period may serve is to introduce 'fringe' subjects, that is, subjects which it may be desirable for the students of any branch of learning to consider, but which cannot conveniently be fitted into the lecture courses.

A few instances of this manner of presenting films are known to be occurring at universities in Great Britain. The fourth-year medical class in public health and social medicine of one British university has a two-hour film session, every week—these sessions to some extent taking the place of visits to institutions of public-health interest. Students in engineering at another British university have—for the past four years—an hour a week of their regular time-table reserved for the showing of films. At the same university films have been shown, by this method, in connexion with the teaching of economics.

Agriculture, anthropology, engineering, estate management, Colonial administration, geography, biology and medicine are all subjects for which—in addition to the lecture method—films can suitably be shown through a separate film session; also film sessions may be useful for languages and art subjects. Students at present have access to libraries for their reference and background reading. Facilities corresponding to these for the viewing of films do not exist.

Apart from the occasional provision of cinema periods by some university departments, the use of films as an aid in university teaching results from the initiative of individual lecturers. It is a use, therefore, which may be fostered by supplying information about films and by providing easy facilities for film projection, and for film-making, and for the viewing and assessing of films. Centralization for film apparatus, technicians and information seems to be the tendency at universities in Great Britain and America.

Universities are centres of research as well as of teaching. Cinematography provides a microscope in time. It may be an instrument of great importance in research work. It allows observations and measurements otherwise impossible. The cracking of glass may be studied, or the mechanism of flight of an insect, or the slow growth and movement of plants and microscopic cells. Films like "Spongilla" and "Cells in Tissue Culture" made by Dr. A. Hughes at the Strangeways Laboratory, Cambridge, are offshoots of research work, in which cinematography is an essential part of the technique used.

There are circumstances in which the impersonal camera must take the place of the human observer, and others in which it can most conveniently be employed. High-tension electrical phenomena may be safely photographed, and illumination outside the visible spectrum may be used. Cinematography may most accurately and conveniently record a number of measuring instruments at the same instant.

As well as providing a valuable tool for actual discovery and measurement in research work, cinematography may be employed to illustrate the phenomena and apparatus. A film may provide a valuable supplement to a written or read description of research work. A number of films that do this have already been made at universities.

There are other connexions in which a university may be concerned with films. Owing to their use in school education, a study of visual aids forms part of the course in the education departments at some universities. Like the longer established arts of literature and music, at some universities abroad film art provides an additional art subject.

A word may be added concerning the important subject of film-making. Nowadays at universities films are made—usually under very restricted conditions—on the initiative of individuals and depart-

ments. Valuable films have been made in this way. But it is possible that in the future universities may concern themselves more directly in this expensive and specialized matter of film production—providing a film unit, or a centre for apparatus and technicians. In many subjects films suitable for university teaching do not at present exist. Where teachers, research workers and apparatus are assembled, it is appropriate that films should be made, and appropriate institutions—like the university presses for the production of books—may eventually come into being.

DIRECTORIES OF PARASITES

THE Specialist Conference (August 1947), on Culture Collections of Micro-organisms, of the British Commonwealth Scientific Official Conference (1946), recommended that a "Directory" of the important culture collections in the Commonwealth should be prepared, and the first issue of a "Directory of Collections of Micro-organisms maintained in the United Kingdom and Crown Colonies" was published in May 1949. It has been compiled by the United Kingdom National Committee of the British Commonwealth Collections of Micro-organisms. This first issue states only the kinds of organisms maintained at each centre listed. It states, that is to say, whether the organisms are viruses, bacteria, protozoa, yeasts, and so on, but not, as yet, the genera and species. A supplementary list to be issued later will give the genera and species.

The lay-out of the "Directory" is not complicated. It allocates to each centre a code number and lists the centres in alphabetical order, commercial laboratories being listed by the name of the firm, non-commercial institutions, university departments and hospitals by the names of the towns in which they are and institutions in the London postal area by their names and not under London, unless their names begin with the word London. An index of the main types of organisms maintained, which includes such items as algæ, bacteria, marine organisms, industrial fermentation, plant pathogens and so on, enables the reader to find, by means of the code numbers, which centres maintain each type of organism. There is also a list of the code numbers with page references. Information is thus easily obtained. The name of the director of each centre is given, together with the name of head of the department maintaining the organisms, the interests of the department, the types of the organisms (and, in most instances, the number of different kinds of them), and whether distribution of them is by personal favour or on request and whether a fee is or is not required.

The "Directory" is bound to be valuable to research workers, and criticism at this early stage in its life would be unfair. In future editions perhaps the use of the term 'director' could be more uniform. In this issue the names of the directors given are sometimes those of the heads of the departments maintaining the organisms and sometimes those of the heads of the centres themselves. The "Directory" is a valuable step in the right direction and all laboratory workers will be grateful for it. It can be obtained free from the Secretary, United Kingdom National Committee of the British Commonwealth Collections of Micro-organisms, 38 Old Queen Street, London, S.W.1, to whom additional information about items in this first issue and also about collections not listed in it, should be addressed.

No less valuable than the "Directory" just discussed are the "Catalogues of Arthropods, Helminths, Molluscs and Protozoa of Interest to Medical and Veterinary Workers", issued on May 9, 1949, from the Laboratory Animals Bureau, Royal Veterinary College, Royal College Street, London, N.W.1. Prepared in collaboration with the organisers of the "Directory of Collections of Micro-organisms", these "Catalogues" are planned on similar lines and use the same code numbers for the centres listed. Fewer centres are given, but, as research workers send in further information, these "Catalogues" will soon grow into the complete directory planned by its organisers. They consist of two lists.

List 1 gives general information, classified by towns, about the parasitic animals and their intermediate hosts that are kept at the various centres listed, with the code number of each centre. Thus we learn from List 1, by looking up London, that Colonel H. E. Shortt, of the Department of Parasitology, London School of Hygiene, maintains five arthropods, eight helminths, eleven molluscs and fifteen protozoa. The number of protozoa maintained by him is by agreement also listed in the "Directory of Micro-organisms". To learn what parasitic animals are kept by Colonel Shortt we look up Colonel Shortt's code number in List 2 of the "Catalogues", which is divided into separate lists of arthropods, helminths, molluscs and protozoa, and gives in most instances their genera and species, the hosts in which they are maintained, the mode of their transmission in the laboratory, the history of the 'strain' kept (when this is known) and the code number of the centre.

The "Catalogues" thus give more information than the "Directory of Micro-organisms" does; but the forthcoming issue of a supplement to the "Directory" containing the species of micro-organisms listed in it will rectify this difference between them. Perhaps in the future it will be possible to combine both directories in one volume. The difficulty of obtaining accurate information of this kind and of keeping it up to date must be very considerable. No doubt this is the reason why the bindings used are not yet permanent, the "Directory" being in a stiff paper binding, the "Catalogues" duplicated. But everyone will be grateful to all those who have helped to produce these lists. It is up to all research workers to help to keep them accurate and up to date by sending to their organisers any information that they may have, not only about items published in these lists, but also about collections of organisms not yet included in them.

G. LAPAGE

FORTHCOMING EVENTS

BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE (at King's College, Newcastle-upon-Tyne).—112th Annual Meeting (Wednesday, August 31—Wednesday, September 7).

Friday, September 2

At 8 p.m. (at the Literary and Philosophical Society, Westgate Road).—Prof. Hans Pettersson: "Exploration of the Ocean Floor".

Saturday, September 3

At 7.30 p.m. (in the City Hall).—Division for Social and International Relations of Science Discussion on "World Food and World Population". (Speakers include: Sir John Russell, F.R.S., Lord Bledisloe, G.C.M.G., Lord Horder, K.C.V.O., Dr. Jaime Torres Bodet, Sir David Rivett, K.C.M.G., F.R.S., and Dr. P. O. Ripley).

Sunday, September 4

At 8 p.m. (at the Literary and Philosophical Society).—Prof. A. D. Ritchie: "The Science of the Living and the Lifeless".

Monday, September 5

At 8 p.m. (at the Literary and Philosophical Society).—Dr. Julian Huxley, F.R.S.: "Reality and Evolution".

Friday, September 9—Sunday, October 2

ROYAL PHOTOGRAPHIC SOCIETY (at 16 Princes Gate, London, S.W.7), at 10 a.m.—Ninety-fourth Annual Exhibition of Photography, Part 1: Pictorial, Colour and Stereoscopic Exhibits.

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

PRESIDENT OF LOUGHBOROUGH COLLEGE—The Director of Education, Grey Friars, Leicester (September 9).

RESEARCH ASSISTANT IN AGRICULTURAL CHEMISTRY—The Registrar, The University, Leeds 2 (September 10).

TECHNICAL ASSISTANT to work on feeding experiments in the Mill Hill area, London, N.W.7—The Establishment Officer, Medical Research Council, 38 Old Queen Street, London, S.W.1 (September 10).

LECTURER (Grade III) IN GEOGRAPHY—The Registrar, Queen Mary College, Mile End Road, E.1 (September 10).

PLANT HELMINTHOLOGIST in the Advisory Entomology Department—The Secretary, Edinburgh and East of Scotland College of Agriculture, 13 George Square, Edinburgh 8 (September 10).

LECTURER IN PHYSICS, and a LECTURER IN CHEMISTRY—The Principal and Clerk to the Governing Body, Wigan and District Mining and Technical College, Wigan (September 10).

BIOCHEMIST to work at the Veterinary Laboratory, Landford, Bristol, on the problem of infertility in domestic animals, and a LECTURER (Grade II) IN ANIMAL HUSBANDRY—The Secretary and Registrar, The University, Bristol (September 17).

ASSISTANT LECTURER IN CHEMISTRY—The Registrar, The University, Sheffield (September 17).

BOTANIST for plant breeding—The Secretary, East Malling Research Station, East Malling, Maidstone, Kent (September 17).

LECTURER (Grade II) IN COAL MINING, and a LECTURER (Grade II) IN METALLIFEROUS MINING—The Secretary, The University, Birmingham 3 (September 17).

LECTURER IN AGRICULTURE—The Secretary, The University, Old College, South Bridge, Edinburgh (September 21).

LECTURER IN ENGINEERING MATHEMATICS in the Department of Natural Philosophy—The Secretary, The University, Aberdeen (September 23).

LECTURER IN PSYCHOLOGY at the New England University College (University of Sydney), Armidale, New South Wales—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (September 23).

ASSISTANT AGRICULTURAL ECONOMIST in the Department of Agriculture—The Registrar, The University, Leeds 2 (September 26).

PROFESSOR OF PURE MATHEMATICS at the Faculty of Science, Farouk I University, Alexandria—The Director, Egyptian Education Bureau, 4 Chesterfield Gardens, London, W.1 (September 30).

FELLOW within the DEPARTMENT OF BIOCHEMISTRY, John Curtin School of Medical Research, Melbourne—The Administrative Officer in the U.K., Australian National University, 6 Gordon Square, London, W.C.1 (September 30).

LECTURER IN CIVIL ENGINEERING in the University of the Witwatersrand, Johannesburg—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (October 3).

ELECTRICAL, ELECTRONIC ENGINEERS (Ref. D.6/49A), and MECHANICAL and AERONAUTICAL ENGINEERS (Ref. C.12/49A) (in Senior Experimental Officer, Experimental Officer and Assistant Experimental Officer grades), at the Royal Aircraft Establishment, Farnborough, and other Ministry of Supply Research and Development Establishments in S. England and the Midlands—The Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting the appropriate Ref. No. (October 12).

PROFESSOR OF MINING ENGINEERING, and a SENIOR LECTURER IN PATHOLOGY, in the University of Queensland—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (October 31).

LECTURER IN THE DEPARTMENT OF AERODYNAMICS—The Registrar, College of Aeronautics, Cranfield, Bletchley, Bucks (December 31).

LORD RUTHERFORD MEMORIAL RESEARCH FELLOWSHIP (subjects: Physics, Chemistry and Mathematics)—The Registrar, Canterbury University College, Christchurch, New Zealand (March 1).

PHYSICISTS for (*a*) fundamental work on the structure and properties of fibrous materials, plasticity and elasticity, etc., (*b*) laboratory and service tests of shoes and shoe materials and manufacturing and development problems—The Director, British Boot, Shoe and Allied Trades Research Association, Satra House, Rockingham Road, Kettering.

RESEARCH ASSISTANT IN THE DEPARTMENT OF THERAPEUTICS AND BIOCHEMISTRY—The House Governor, General Hospital, Birmingham 4.

RESEARCH STUDENTSHIP IN THE DEPARTMENT OF FORESTRY for the study of morphological and silvicultural variations in coniferous species—The Secretary, The University, Marischal College, Aberdeen.

PLANT MANAGER to be responsible for the operation of a section of a large chemical plant at Springfields Factory, Salwick, near Preston—The Staff Section, Ministry of Supply, Division of Atomic Energy (Production), Risley, Warrington, Lancs.

SENIOR AGRICULTURAL OFFICER to take charge of the Agricultural Department—The Director, South African Sugar Association, Sugar Experiment Station, Mount Edgecombe, Natal, South Africa.

SPECIAL TECHNICIAN for work in the field of electronics as applied to the biological sciences—The Secretary, University Court, The University, Glasgow, W.2.

TECHNICIAN FOR PHYSICIST'S DEPARTMENT—The Administrative Officer, Royal Berkshire Hospital, Reading.

LABORATORY ASSISTANT to take charge of stock and preparation of large classes in science up to Higher School Certificate standard—The Headmistress, Dartford County Grammar School for Girls, Shepherds Lane, Dartford, Kent.

MAN (preferably married) to take charge of laboratory animals—The Bursar, Royal Veterinary College and Hospital, Royal College Street, London, N.W.1.

ASSISTANT LECTURER IN INVERTEBRATE ZOOLOGY in the Department of Zoology and Applied Entomology—H. R. Hewer, Imperial College of Science and Technology, South Kensington, London, S.W.7.

AGRICULTURAL or SOIL CHEMIST at the Tea Research Institute of Ceylon—The Secretary, Ceylon Association in London, King William Street House, Arthur Street, London, E.C.4.

LECTURER IN PHYSICAL CHEMISTRY to Honours Degree standard—The Principal, Municipal Technical College, Halifax.

RESEARCH CHEMIST (Honours Degree standard, preferably with an interest in biochemical problems)—The Secretary, British Jute Trade Research Association, Kinnoull Road, Kingsway West, Dundee.

VETERINARY RESEARCH OFFICER for service in the Sudan—The Sudan Agent in London, Wellington House, Buckingham Gate, London, S.W.1, endorsed 'Veterinary Research Officer'.

CHEMISTS IN THE JOINT DEPARTMENT OF CHEMISTRY, Federation of Malaya and Singapore—The Director of Recruitment (Colonial Service), Sanctuary Buildings, Great Smith Street, London, S.W.1.

DIRECTOR OF THE WEST AFRICAN AGRICULTURE AND FORESTRY RESEARCH ORGANISATION—The Under-Secretary of State, Colonial Office, Research Department, Sanctuary Buildings, Great Smith Street, London, S.W.1.

ASSISTANT LECTURER IN PHYSICAL CHEMISTRY, and an ASSISTANT REGISTRAR—The Registrar, The University, Nottingham.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Other Countries

Bulletin of the American Museum of Natural History. Vol. 93, Article 3: Promerycochoerinae, a New Subfamily of Oreodons. By C. Bertrand Schultz and Charles H. Falkenbach. Pp. 69–198. 8.p. Vol. 93, Article 4: A Revision of the Bird Family Dicruridae. By Charles Vaurie. Pp. 199–342. 1.75 dollars. (New York: American Museum of Natural History, 1949.) [28

Proceedings of the American Philosophical Society. Vol. 93, No. 2: Studies of Historical Documents in the Library of the American Philosophical Society. Pp. 97–208. (Philadelphia: American Philosophical Society, 1949.) 1 dollar. [28

American Philosophical Society. Year Book 1948. Pp. 446. (Philadelphia: American Philosophical Society, 1949.) [28

Report of the Science Service, Dominion Department of Agriculture, for the Year ended March 31, 1948. Pp. 9–108. (Ottawa: King's Printer, 1949.) [28

Report on General Survey of British Somaliland, 1947. (Published under the authority of the British Military Administration, Somaliland Protectorate.) Pp. 26. (Burao: British Military Administration, 1948.) 6s. [28

Istituto Superiore di Sanità. Rendiconti, Vol. 12, Parte 1-2-3: Numero speciale sui Curari di sintesi. Pp. 264. (Roma: Emanuele Paterno, 1949.) [28

Conference on Metabolic Aspects of Convalescence. Transactions of the Sixteenth Meeting, New York, October 27–28, 1947. Edited by Dr. Edward C. Reifenstein, Jr. Pp. 168. 3 dollars. Transactions of the Seventeenth Meeting, New York, March 29–30, 1948. Edited by Dr. Edward C. Reifenstein, Jr. Pp. 246. 4 dollars. (New York: Josiah Macy Jr. Foundation, 1948–1949.) [28

Union Géodés que et Géophysique Internationale. Huitième assemblée générale réunie à Oslo, 19–28 août 1948. Edited by Dr. J. M. Stagg. Pp. 170. (Richmond, Surrey: Dr. J. M. Stagg, 34 King's Road, 1949.) [28

University of Illinois Engineering Experiment Station. Bulletin No. 377: Flexural Fatigue Strength of Steel Beams. By Wilbur M. Wilson. Pp. 32. 20 cents. Bulletin No. 378: An Investigation of Creep, Fracture and Bending of Lead and Lead Alloys for Cable Sheathing, Series 1946. By Curtis W. Dollins. Pp. 87. 50 cents. Bulletin No. 379: Non-Pressure Treatments of Round Northern White Cedar Timbers with Creosote. By Everett Edgar King. Pp. 60. 20 cents. (Urbana, Ill.: University of Illinois, 1948.) [28

University of Illinois Engineering Experiment Station. Circular No. 50: Bibliography of Electroorganic Chemistry, Part 1. By Sherlock Swann, Jr. Pp. 114. 1 dollar. Circular No 53: Papers presented at the Seventh Short Course in Coal Utilization held at the University of Illinois, September 17–19, 1946. Pp. 192. 1 dollar. Circular No. 54: Papers presented at the First Short Course on Hot Water and Steam Heating Systems held at the Undergraduate Division, University of Illinois, Navy Pier, Chicago, September 9–11, 1947. Pp. 108. 50 cents. (Urbana, Ill.: University of Illinois, 1948.) [28

University of Illinois Engineering Experiment Station. Reprint No. 39: Progress Reports of Investigation of Railroad Rails and Joint Bars. By R. E. Cramer and R. S. Jensen. Pp. 35. 15 cents. Reprint No. 40: Third Progress Report of the Investigation of Methods of Roadbed Stabilization. By Rockwell Smith. Pp. 24. 15 cents. Reprint No. 41: Phase-sensitive Indicating Devices. By Howard C. Roberts. Pp. 18. 15 cents. (Urbana, Ill.: University of Illinois, 1948.) [28

Vegetationskarte der Schweiz. Herausgegeben von der Pflanzengeographischen Kommission der Schweizerischen Naturforschenden Gesellschaft. Aufnahmen und Bearbeitung von Prof. Dr. Emil Schmid. Massstab 1:200,000. Blatt Nr. 1: Bern, Neuenberg, Basel, Aarau. 37 in. × 26¼ in. 12 francs. Blatt Nr. 4: Gotthard–Tessin–Grisons. 37 in. × 26¼ in. 12 francs. (Bern: Hans Huber, 1949.) [28